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# USSR Report

PHYSICS AND MATHEMATICS



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11 April 1985

# USSR REPORT

## PHYSICS AND MATHEMATICS

### CONTENTS

#### CRYSTALS AND SEMICONDUCTORS

- Ultraviolet Luminescence Due to Interconfigurational Electron Transitions in Yttrium-Aluminum Garnet Crystals Activated by Prasiodymium  
(M. L. Meyl'man, A. I. Kolomiitsev, et al.; OPTIKA I SPEKTROSKOPIYA, No 2 Aug 84)..... 1
- Raman Scattering of Light in Epitaxial Films of Solid Phosphide-Gallium Arsenide Solutions  
(V. S. Gorelik, R. N. Khashimov, et al.; FIZIKA I POLUPROVODNIKOV, No 8, Aug 84)..... 1
- Dynamics of Recrystallization and Redistribution of Impurities in Semiconductors Subjected to Millisecond Laser Pulses  
(S. G. Kiyak, A. K. Zhukhostanov, et al.; FIZIKA I TEKHNIKA POLUPROVODNIKOV, No 8, Aug 84)..... 2
- Spontaneous Amplification of Permittivity Modulation of Germanium Surface Caused by Powerful Light Wave  
(I.A. Avrutskiy, P.V. Bazakutsa, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 18, 26 Sep 84)..... 2

#### FLUID DYNAMICS

- Numerical Analysis of Supersonic Reactive Flow in Wake of Reverse Step  
(N. N. Yanenko, V.I. Golovichev; FIZIKA GORENIYA I VZRYVA, No 4, Jul-Aug 84)..... 4

Experimental Investigation of Effect of Single-Layer Compliant Coatings on Turbulent Friction and Pressure Pulsations on Wall (V. M. Kulik, I.S. Poguda, et al.; INZHENERNO-FIZICHESKIY ZHURNAL, No 2, Aug 84).....	4
Escape of Self-Evaporating Nitrogen From Laval Nozzles (V. V. Usanov, V. M. Kharchenko; TEPLOFIZIKA VYSOKIKH TEMPERATUR, No 4, Jul-Aug 84).....	5
Numerical Modeling of Gas Dynamic Phenomena During Supersonic Flow of Viscous Gas in Channel with Electrical Glow Discharge (P.A. Voynovich, B.M. Dymshits, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 15, 12 Aug 84).....	5
Occurrence of Inverse Population in Non-Steady-State Expansion Waves Following Cutoff of Supersonic Nozzle (Yu.I. Grin', V.G. Testov, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jul 84).....	6
Numerical Modeling of Unsteady Periodic Viscuous Flow in the Wake of a Cylinder (O. M. Belotserkovskiy, S.O. Belotserkovskiy, et al.; ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 8, Aug 84).....	6
Possible Causes for Spread in Experimental Characteristics of Detonation Waves (V. N. Zubarev, A. A. Yervstigneyev; DOKLADY AKADEMII NAUK SSSR, No 4, Aug 84).....	7
Experimental Investigation of Light Scattering on Shape Fluctuations of Liquid Droplets (V. I. Kalechits, I. Ye. Nakhutin, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 8, Aug 84).....	7

#### LASERS & MASERS

Characteristics of Laser Emission Discharge Created by Pulsed CO <sub>2</sub> -Laser (E. M. Barkhudarov, G. V. Gelashvili, et al.; FIZIKA PLAZMY, No 4, Jul-Aug 84).....	9
Initiation of H <sub>2</sub> +F <sub>2</sub> -Laser by Multi-Photon Dissociation of Sodium Hexachloride (M. S. Kurdoglyan, A. N. Orayevskiy; KHIMIYA VYSOKIKH ENERGIY, No 5, Sep-Oct 84).....	9



Influence of Added Hydrogen and Xenon on Chemical Composition of Plasma of Waveguide CO <sub>2</sub> Laser (V. I. Volchenok, V. N. Komarov, et al.; KHIMIYA VYSOKIKH ENERGIY, No 5, Sep-Oct 84).....	10
Theoretical Investigation of Lasing in 4.3 $\mu$ m Region in CO <sub>2</sub> Laser (M. M. Ivanenko, S.A. Trushin, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 3, Sep 84).....	10
Reduction in Q-Factor of Laser Cavity as Optical Length Becomes Shorter (A.P. Voytovich, S.I. Ovseychik, et al.; DOKLADY AKADEMII NAUK BSSR, No 10).....	11
Acceptable Heat Loads of Non-Uniformly Illuminated Cooled Laser Mirrors (V. V. Kharitonov, P.A. Grishunin, et al.; INZHENERNO-FIZICHESKIY ZHURNAL, No 2, Aug 84).....	11
Lasing in In <sub>0.53</sub> Gd <sub>0.47</sub> As/InP Layers ( $\lambda = 1.53 \mu$ m) Subjected to Optical Pumping (L.L. Kulyuk, S.I. Radautsan, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 18, 26 Sep 84).....	12
Submillimeter-Band Solid State Distributed Feedback Laser (A.G. Aleksanyan, G.P. Boyakhchyan, et al.; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 4, Jul-Aug 84).....	12
Excitation and Maintenance of Long Spark by Radiation from Free-Running Laser (V. M. Gavrilov, S. L. Golub, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 9, Sep 84).....	13
Waveguide Phenomena in Dense Relaxing Gases and Their use in Chemical and Gas-Dynamic Lasers (B. D. Barmashenko, V. A. Kochelap, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 9, Sep 84).....	13
New Honeycomb Nozzle Module for Gasdynamic Lasers (O. V. Achasov, A. S. Boreysho, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 9, Sep 84).....	14
Laser R&D Cooperation Between Physics Institutes (R. Chesna; SOVETSKAYA BELORUSSIYA, 23 Sep 84).....	15
Two-Photon Modulation of Radiation from Distributed Feedback Laser (R.A. Karamaliyev, DAO SUAN KHOY; IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-TEKHNIЧЕСКИKH I MATEMATIЧЕСКИKH NAUK, No 1, Jan-Feb 84).....	16

Amplification of Scattered Induced Radiation Flux in High-Gain Laser Rods (B.S. Skorobogatov, A. I. Usoskin; OPTIKA I SPEKTROSKOPIYA, No 6, Jun 84).....	16
Industrial Laser Use Expanding in USSR (Ye. P. Velikhov; EKONOMICHESKAYA GAZETA, April 1983)...	18
Mode Locking in Ring Lasers with Nonlinear Absorber (P. S. Landa, V. N. Moyiseyev; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84).....	24
Self-Consistent Method for Designing Laser Pumping Systems. Characteristics of Pumping Systems with Inhomogeneous Temperature Distribution in Lamp Discharge (V. M. Gradov, A. A. Mak, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84).....	24
Investigation of Laser Characteristics of Water-Soluble Dyes for Blue-Green Region of Emission Spectrum (M. I. Dzyubenko, I. P. Kraynov, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84).....	25
State Prize Nomination for Work on Parametric Tunable Lasers (R. Chesna; SOVETSKAYA LITVA, 21 Oct 84).....	26
Industrial Lasers Center's Research Role, Expansion Plans (A. Pankov; LENINSKOYE ZNAMYA, 2 Oct 84).....	27
Low-Threshold InGaAsP/InP MesaStrip Continuous Lasers ( $\lambda \approx 1.3 \mu\text{m}$ ) (Zh. I. Alferov, K. A. Gatsoyev, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 16, 26 Aug 84).....	29
Supersonic CO-Laser With Atomic Oxygen Source Based on CS <sub>2</sub> /O <sub>2</sub> Flame (V. A. Dudkin, V. A. Ogurechnikov; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 16, 26 Aug 84).....	29
Diffraction Nonreciprocity of Counter Propagating Wave Generation in Ring Laser with Weak Diffraction (Yu. V. Glushchenko, T. V. Radina, et al.; OPTIKA I SPEKTROSKOPIYA, No 2, Aug 84).....	30
Mechanism of Low Frequency Output Power Fluctuations of Gas-Discharge Lasers (G. V. Melekhin, V. A. Stepanov, et al.; OPTIKA I SPEKTROSKOPIYA, No 2, Aug 84).....	31

Mode Interaction in Multifrequency Gas Ring Laser (A. P. Kiriyeveskiy, M. O. Nikonchuk, et al.; OPTIKA I SPEKTROSKOPIYA, No 2, Aug 84).....	31
Influence of Aperture Misalignment on Non-Reciprocity of Counter-Propagating Waves in Ring Laser (V. F. Boytsov; OPTIKA I SPEKTROSKOPIYA, No 2, Aug 84).....	32
Self-Defocusing of Converging Laser Beams (Yu.K. Danileyko, L.M. Degtyarev, et al.; ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 3 (9), Sep 84).....	32

#### MOLECULAR PHYSICS

Quantum-Mechanical Calculation of Diffusion Coefficients of Metal Vapors in Gases (K. M. Aref'yev, M. A. Guseva; INZHENERNO-FIZICHESKIY ZHURNAL, No 4, Oct 84).....	33
Dissociation of Polyatomic Molecules Caused by IR Laser Radiation (A Review) (L. I. Trakhtenberg, G. M. Milikh; KHIMIYA VYSOKIKH ENERGIY, No 5, Sep-Oct 84).....	33
Determination of P <sub>2</sub> O <sub>5</sub> in Phosphate-Silicate Glasses (Ya. S. Kamentsev, N. K. Gornovskaya; VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA, No 3, Aug 84).....	34
Laser-Initiated Phase Transition in Chemically Active Medium (F. V. Bunkin, N. A. Kirichenko; DOKLADY AKADEMII NAUK SSSR, No 6, Aug 84).....	34
Iron Alloying by Carbon During Gas Breakdown at Atmospheric Pressure by Radiation from Pulse-Periodic CO <sub>2</sub> Laser (V. N. Anisimov, V. Yu. Baranov, et al.; POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA, No 9, Sep 84).....	35
Characteristics of Laser Heating of Metal in Oxidizing Atmosphere (N. N. Rykalin, A. A. Uglov, et al.; DOKLADY AKADEMII NAUK SSSR, No 6, Aug 84).....	35
Spectral-Phase Effects and Selective Detection of Compounds Based on Example of Iodine (A.A. Ganeyev, V.A. Novikov, et al.; ZHURNAL TEKHNICHESKOY FIZIKI, No 7, Jul 84).....	36

Investigation of Four-Step Scheme for Separating Ytterbium Isotopes with Laser Radiation (S.K. Borisov, S.A. Kotochigova, et al.; ZHURNAL TEKHNICHESKOY FIZIKI, No 7, Jul 84).....	36
NUCLEAR PHYSICS	
Breakthrough in Container Confinement of Ultracold Neutrons (V. Okolotin; MOSKOVSKIY KOMSOMOLETS, 3 Oct 84).....	38
Solar Wind and Cosmic Rain (B. Konovalov; IZVESTIYA, 3 Sep 84).....	40
OPTICS & SPECTROSCOPY	
Using Laser Correlation Spectroscopy Method to Determine Content of Gaseous Mixtures (O.D. Kraysler, V.L. Goldovskiy, et al.; OPTIKA I SPEKTROSKOPIYA, No 2, Aug 84).....	44
Use of Flashlamp-Pumped Frequency-Tunable Dye Lasers for Genetic Selection Research (V. A. Mostovnikov, S. V. Nechayev, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 3, Sep 84).....	44
Influence of Illumination of Galvanomagnetic Characteristics of Two-Dimensional Electron Gas in Strong Magnetic Fields (V.B. Anzin, V.G. Veselago, et al.; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 6, 25 Sep 84).....	45
Coherent Component of Light Field Scattered by Single Layer of Particles (V.P. Dik, V.A. Loyko, et al.; DOKLADY AKADEMII NAUK BSSR, No 10).....	45
EPR Laser Spectrometer Developed at Chemical Physics Institute (M. Kochunov; SOTSIALISTICHESKAYA INDUSTRIYA, 19 Jul 84).....	47
Laser Aerosol Spectrometer (MOSKOVSKAYA PRAVDA, 10 Jul 84).....	48
Laser Fluorimeter for Water Pollution Monitoring (KAZAKHSTANSKAYA PRAVDA, 22 Aug 84).....	49
Investigation of Bichromated-Gelatin Hologram Elements for Converting Spatial Structure of Laser Radiation (B.O. Mayer, D.I. Stasel'ko, et al.; OPTIKA I SPEKTROSKOPIYA, N 6, Jun 84).....	50



Spectral Behavior of Coefficient of Reflection of Bragg Reflector (S.A. Gurevich, S. Yu. Karpov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 15, 12 Aug 84).....	50
Determination of Integral Characteristics of Size Distribution Density Function of Sub-Micron Fraction of Aerosols Using Optical Measurement Data (A.P. Chaykovskiy, V.N. Shcherbakov, et al.; DOKLADY AKADEMII NAUK BSSR, No 9, Sep 84).....	51
Interference Reflectors with Glancing Incidence of Light (A. Yu. Klement'yeva; VESTNIK MOSKOVSKOGO UNIVERSITETA: SERIYA 3 FIZIKA, ASTRONOMIYA, No 4, Jul-Aug 84).....	51
A Continuous Approach to Considering Influence of Multiple Scattering on Emission of High-Energy Particles in Crystalline and Amorphous Media (N. V. Laskin, A.S. Mazmanishvili, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Aug 84).....	52
Overfocusing Effect of Optical System with Metal-Dielectric-Semiconductor - Liquid Crystal Structure (Yu. D. Dumarevskiy, N. F. Kovtonyuk, et al.; DOKLADY AKADEMII NAUK SSSR, No 6, Aug 84).....	52
Spatial Coherence of Field of Spherical Wave Reflected in Turbulent Atmosphere (V. P. Aksenov; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84)...	53
Optimization of Light Beam with Gaussian Intensity Distribution in Diffraction-Limited Optical Energy Transmission Systems (V. B. Fedorov, V.G. Mityakov; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84).....	53
Pulsed Fourier Optics (Yu. T. Mazurenko; OPTIKA I SPEKTROSKOPIYA, No 1, Jul 84).....	54
Use of Mid-IR Band Diode Lasers in Spectral Gas Analysis (I. I. Zasavitskiy, Yu. V. Kosichkin, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 8, Aug 84).....	54

#### OPTOELECTRONICS

Radar Measurement of Thickness of Drifting Ocean Ice Employing Cepstral Signal Processing (V. V. Bogorodskiy, V. I. Boyarskiy, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 7, Jul 84).....	56
---	----



## PLASMA PHYSICS

Development of Theory of High-Current High-Pressure Pulsed Arc (V. V. Korneyev, A. N. Lobanov, et al.; ELEKTRICHESTVO, No 9, Sep 84).....	57
Radiation Collimation of Atomic Beam by Two-Dimensional Laser Cooling (V.I. Balykin, V. S. Letokhov, et al.; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 6, 25 Sep 84).....	57
Nonlinear Waves in Plasma in Strong Magnetic Fields (V. I. Berezhiani, N. L. Shatashvili; SOOBASHCHENIYA AKADEMII NAUK GRUZINSKOY SSR, No 2, May 84).....	58
Two-Dimensional Model of Plasma Near Wall of Tokamak with Polhodal Diverter (Yu.L. Igitkhanov, A.S. Kukushkin, et al.; DOKLADY AKADEMII NAUK SSSR, No 2, Sep 84).....	58
Spread-Function Comparison of Different Probe Methods for Measuring Electron Energy Distribution in Plasma (L. M. Vokkova, V.I. Demidov, et al.; TEPILOFIZIKA VYSOKIKH TEMPERATUR, No 4, Jul-Aug 84).....	59
Initial Stage of Discharge Through Metal Wires in High- Current Accelerator Diode (S.M. Zakharov, G.M. Ivanenkov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 18, 26 Sep 84).....	60
Investigation of Relaxation Processes of Excited State Popula- tions in Plasma Produced by Powerful Nanosecond Pulse Dis- charge in Neon (N.A. Ashurbekov, V.S. Yegorov, et al.; VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA, No 3, Aug 84).....	60
Thresholds of Occurrence of Different States of Non-Equilibrium Ionized Surface Plasma Initiated by Action of Laser Radia- tion on Metals (V.S. Vorob'ev, A.L. Khomkin; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 5, 12 Aug 84).....	61
Formation of Ion Beams with High Phase Density of Current Non-Steady-State From Plasma as Applied to Development of Ion Sources (T.A. Basova, Yu. A. Bykovskiy, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 8, Aug 84).....	61

Investigation of Dense Cluster Plasma Formed by Electron Beam (I. P. Stakhanov; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 8, Aug 84).....	62
The Role of Recoil in Quantum Modulation Effect of Charged Particle Beams (S. G. Oganessian, V. A. Yengibaryan; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 8, Aug 84).....	62
Laser-Plasma Detection of Difference Frequency of Two Lightwaves (N.G. Basov, B.I. Vasil'ev, et al; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 3, 10 Aug 84).....	63
One-Dimensional Gas Dynamic Modeling of Electron Beam Trans- port in Rarified Gas (A. V. Mikhaylov, G.I. Guseva, et al.; ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 3, (9), Sep 84).....	63
Experimental and Theoretical Findings on Irradiation of Spherical Microtargets by Terawatt Iodine Laser (Ye.N. Avrorin, V.A. Yeroshenko, et al.; ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 2, Aug 84).....	64
Study of Breakdown in Ar and He at Low Pressures by CO <sub>2</sub> -Laser Radiation (N.P. Datskevich, N.V. Karlov, et al.; FIZIKA PLAZMY, No 4, Jul-Aug 84).....	64
Conversion of Kinetic Energy of Supersonic Plasma Flows to Short-Wave Radiation During Impact Against Wall (M.F. Gryukanov, I.K. Konkashbayev; FIZIKA PLAZMY, No 4, Jul-Aug 84).....	65
Runaway Electrons and Plasma Turbulence in Stellarator with Ohmic Current (Ye. D. Volkov, N.F. Perepelkin, et al.; FIZIKA PLAZMY, No 4, Jul-Aug 84).....	65
Use of Impulse Probe for Stationary Dense Plasma Diagnostics in Presence of Chemical Reactions (G.S. Aravin, P.A. Vlasov, et al.; FIZIKA GORENIYA I VZRYVA, No 4, Jul-Aug 84).....	66
Possible Mechanism Underlying Contamination of Plasma in Thermonuclear Installations by Volatile Impurities (V.S. Voytsenya, V.V. Vasil'ev; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 7, Jul 84).....	66

High-Efficiency Conversion of Laser Radiation in Plasma to Soft X-rays (Yu. S. Kas'yanov, Yu.S. Leonov, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 7, Jul 84).....	67
Plasma Screening Effect About Quasi-Neutral Bunch of Negative Ions (V.P. Goretskiy, A.P. Nayda, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 7, Jul 84).....	67
STRESS, STRAIN AND DEFORMATION	
Shock-Wave Deformation of Titanium Carbide Ceramic (G.I. Kanel', A.N. Pityulin; FIZIKA GORENIYA I VZRYVA, No 4, Jul-Aug 84).....	68
Numerical Modeling of High Speed Impact for Different Density Ratios of Impactor and Target (Yu.G. Malama; FIZIKA GORENIYA I VZRYVA, No 4, Jul-Aug 84).....	68
THERMODYNAMICS	
Heating of Thin Films by Laser Radiation Considering Temperature Behavior of Coefficient of Reflection (S.N. Kapel'yan, Yu. F. Morgun; INZHENERNO-FIZICHESKIY ZHURNAL, No 4, Oct 84).....	69
Low-Temperature Thermal Expansion of Glass (Yu.M. Gal'perin, V.L. Gurevich, et al.; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 7, 10 Oct 84).....	69
Assessment of Influence of Subsurface Layers on Measured Noise Temperature of Ballistite Powder (V.M. Zenchenko, Yu.S. Ivashchenko; FIZIKA GORENIYA I VZRYVA, No 4, Jul-Aug 84).....	70
MATHEMATICS	
Sufficient Minimum Conditions for Nonlinear Programming Problems (Yu.G. Yevtushenko, V.A. Purtov; DOKLADY AKADEMII NAUK SSSR, No 1, Sep 84).....	71
The Nature of Undulatory Oscillations of Fish Bodies (Ye. D. Sorokodum; DOKLADY AKADEMII NAUK SSSR, No 3, Sep 84).....	71

Properties of Random Sub-Gaussian Type Processes (Yu.V. Kozachenko; DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI, No 9, Sep 84).....	72
A Necessary Condition for Optimality of Stochastic Control Systems (R.N. Tevzadze; SOOBShCHENIYA AKADEMII NAUK GRUZINSKOY SSR, No 1, Apr 84).....	72
Control of Nonstationary Object with Controlled Observation Process (A.Kh. Abramov, N.D. Dagkesamanskiy; IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-TEKHNIЧЕСKIKH I MATEMATICHESKIKH NAUK, No 1, Jan-Feb 84).....	73
An Optimality Criterion for a Decoding Algorithm for Monotonic Boolean Functions (D. N. Gaynanov; ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 8, Aug 84).....	73
New Approach to Frequency Processing in Method of Observation Grouping and Optimality of Chi-Square Criterion (G.I. Ivchenko, S.V. Tsukanov; DOKLADY AKADEMII NAUK SSSR, No 2, Jul 84).....	74
Solution of Linear Differential Tracking Game Without Discrim- ination of a Retreating Object (I.S. Pontryagin, A.S. Mishchenko; DOKLADY AKADEMII NAUK SSSR, No 5, Aug 84).....	74
Solution of Linear Differential Tracking Game Based on Alter- nated Integration Without Discrimination of Retreating Control (L. S. Pontryagin, A.S. Mishchenko; DOKLADY AKADEMII NAUK SSSR, No 6, Aug 84).....	75
Controlling Stability of Explicit Single-Step Methods for Integrating Ordinary Differential Equations (V.A. Novikov, Ye. A. Novikov; DOKLADY AKADEMII NAUK SSR, No 5, Aug 84).....	75

CRYSTALS AND SEMICONDUCTORS

UDC 535.37-3:548.0

ULTRAVIOLET LUMINESCENCE DUE TO INTERCONFIGURATIONAL ELECTRON TRANSITIONS  
IN YTTRIUM-ALUMINUM GARNET CRYSTALS ACTIVATED BY PRASIODYMIUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 2, Aug 84  
(manuscript received 31 Mar 82) pp 239-241

MEYL'MAN, M.L., KOLOMIYTSYEV, A. I., KEVORKOV, A. M. and BAGDASAROV, Kh. S.

[Abstract] The absorption spectra, luminescence and excitation of photoluminescence YAG-Pr single crystals in the ultraviolet region  $5 \cdot 10^4 \text{ cm}^{-1}$  are measured. The YAG specimens were grown by vertical directed crystallization from a melt in a 0.2-0.8%  $\text{PrO}_3$  by weight. The absorption spectra are measured at 77 and 295K on a Perkin-Elmer 554 spectrophotometer; the emission and luminescence excitation spectra are measured on a Perkin-Elmer MPF44A spectrofluorometer. No transitions associated with the term  $^1S_0$  were observed: it is apparently the case that the shift of that level in YAG in relation to its position for a free  $\text{Pr}^{3+}$  ion is significantly smaller than for crystals such as  $\text{LaF}_3$ ,  $\text{YPO}_4$ , etc. References 8: 2 Russian, 6 Western.  
[66-6900]

RAMAN SCATTERING OF LIGHT IN EPITAXIAL FILMS OF SOLID PHOSPHIDE-GALLIUM  
ARSENIDE SOLUTIONS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 18, No 8, Aug 84  
(manuscript received 2 Mar 84 after revision) pp 1403-1407

GORELIK, V. S., KHASHIMOV, R. N. and VIDANOV, A. P., Physics Institute  
Imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A method is proposed for using Raman light scattering spectra to investigate epitaxial films of  $\text{GaP}_{1-x}\text{As}_x$  grown on gallium phosphide substrates. An oblique cut of a  $\text{GaP}_{1-x}\text{As}_x$  film was investigated in order to study the characteristics of the transitional layer. The Raman scattering data are compared with the results of investigating the same specimen using the X-ray microanalysis method. The optical phonon frequencies corresponding to vibrations of the crystal sublattice of phosphorus are shown to



decrease linearly as the concentration of  $x$  increases from 0 to 0.16. It is shown that the Raman scattering method can be used to monitor the concentration of solid solution components and to study their vertical distribution through the film. References 8: 3 Russian, 5 Western. [65-6900]

DYNAMICS OF RECRYSTALLIZATION AND REDISTRIBUTION OF IMPURITIES IN SEMICONDUCTORS SUBJECTED TO MILLISECOND LASER PULSES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 18, No 8, Aug 84 (manuscript received 4 Apr 84 after revision) pp 1446-1449

KIYAK, S. G., SHUKHOSTANOV, A. K., SAVITSKIY, G. V., GONOV, S. Zh. and GAFIYCHUK, V. V., Institute of Applied Problems and Mechanics and Mathematics, Ukrainian SSR Academy of Sciences

[Abstract] The kinetics of millisecond laser pulses acting upon semiconductors are investigated by reflecting probing radiation from the irradiated surface of the crystal. The characteristics of fusion, recrystallization and impurity redistribution associated with the spike nature of laser radiation in the free lasing mode are investigated. The temporal characteristics of fusion and recrystallization were investigated on germanium specimens by charting the variation in intensity of probing radiation from an LG52-1 helium-neon laser reflected from the surface. The surface layer of the crystals was heated and fused by radiation from a GOS-301 neodymium-laser. It is found that millisecond laser pulses (under optimum conditions) can produce uniformly recrystallized layers with modified physical and mechanical characteristics. The influence of segregation effects and impurity evaporation processes on the properties of the recrystallized layers is discussed. The radiation mode employed can be used to remove adsorbed layers from the crystal surfaces, and to eliminate reaction products formed during chemical treatment of the material. References 8: 3 Russian, 5 Western. [65-6900]

SPONTANEOUS AMPLIFICATION OF PERMITTIVITY MODULATION OF GERMANIUM SURFACE CAUSED BY POWERFUL LIGHT WAVE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 10, No 18, 26 Sep 84 (manuscript received 16 May 84) pp 1089-1093

AVRUTSKIY, I.A., BAZAKUTSA, P.V., PROKHOROV, A.M., SYCHUGOV, B.A. and TISHCHENKO, A.V., Institute of General Physics, USSR Academy of Sciences

[Abstract] The problem of light diffraction on a lattice formed by modulation of permittivity of the medium and spontaneous amplification of the lattice caused by incident light is investigated in order to determine the causes for the formation of longitudinal corrugation. Zero- and first-order

diffraction is considered for solid and for liquid germanium. The difference between the energy deposited in the peaks and valleys of the corrugations is investigated as a function of the quantity  $\lambda/\Lambda$  ( $\lambda$  - wavelength of perturbing light,  $\Lambda$  - period of corrugation) for TM-polarized light. It is found that the function  $\Delta Q(\lambda/\Lambda)$  changes significantly as the angle of incidence becomes larger, with maxima occurring near  $\lambda/\Lambda = \cos\theta$ . Experiments are described in which germanium was irradiated by TM-polarized light in order to find which of the extrema results in the formation of corrugation. It is found that corrugation begins to form due to amplification of the modulation of the permittivity in solid germanium. References 5: 3 Russian, 2 Western.  
[90-6900]

FLUID DYNAMICS

NUMERICAL ANALYSIS OF SUPERSONIC REACTIVE FLOW IN WAKE OF REVERSE STEP

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 4, Jul-Aug 84  
(manuscript received 29 Jul 83) pp 52-56

YANENKO, N. N. (deceased) and GOLOVICHEV, V.I., Novosibirsk.

[Abstract] The effectiveness of radial injection of fuel into a chamber is investigated for the case in which the jet injected parallel to the axis (or plane) of symmetry of the flow is not completely expanded. The flow is described by solving the complete time-dependent viscous gas dynamic equations (Navier-Stokes equations) in conjunction with the mass transfer equations of the individual components of the mixture, in which the source terms describe all of the nonequilibrium physical-chemical processes occurring in the flow. A five-component gas mixture is analyzed in which two chemical reactions occur and in which the power profile and kinetic parameters approximately describe the mechanism of hydrogen combustion in air. The most complete combustion is obtained by feeding in additional fuel by injecting a sonic jet of hydrogen through an additional injector in the center of the channel. References 5: 4 Russian, 1 Western.  
[29-6900]

UDC 532.526.4

EXPERIMENTAL INVESTIGATION OF EFFECT OF SINGLE-LAYER COMPLIANT COATINGS ON TURBULENT FRICTION AND PRESSURE PULSATIONS ON WALL

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 47, No 2, Aug 84  
(manuscript received 30 May 83) pp 189-196

KULIK, V. M., POGUDA, I. S. and SEMENOV, B. N., Institute of Heat Physics, Siberian Department, USSR Academy of Sciences

[Abstract] The correlation between the turbulent friction and pressure pulsations on a wall with the oscillatory characteristics of the wall are studied for single-layer coating. Turbulent friction and pressure pulsations are found to be a strong function of the velocity and temperature of the water. The spectral density of pressure pulsations at frequencies

exceeding 2 KHz drops off by 2-3 dB near a viscoelastic wall in spite of increased friction and mean square pressure pulsations. The variation in friction and mean square pressure pulsations in the 500-6000 Hz region are practically the same, suggesting that the Kreichnan coefficient remains the same when a viscoelastic boundary is introduced. References 17: 10 Russian, 7 Western.  
[36-6900]

UDC 532.525

#### ESCAPE OF SELF-EVAPORATING NITROGEN FROM LAVAL NOZZLES

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 22, No 4, Jul-Aug 84  
(manuscript received 12 Apr 83) pp 739-744

USANOV, V. V. and KHAZHENKO, V. M., All-Union Scientific Research for Helium Engineering

[Abstract] The flow of nitrogen from axisymmetrical Laval nozzles with apertures of 10 and 16° is investigated experimentally for initial temperatures ranging from 90 to 150 K and initial pressures ranging from values close to the saturated liquid curve to 70.6 MPa. The flow process in the nozzle is described on the basis of a model of iso-entropic expansion which is in equilibrium in the two-phase region. It is noted that the model may differ significantly from the real process because of delayed vapor formation. The flow characteristics of the nozzles are obtained, and the minimum initial pressure above which the true flow rate becomes smaller than that calculated by the model is found as a function of the initial temperature. The experimental data indicate the absence of any influence of metastability on the flow characteristics at high initial pressures in the range of initial temperatures investigated. Figures 5; references 9: 5 Russian, 4 Western.  
[34-6900]

#### NUMERICAL MODELING OF GAS DYNAMIC PHENOMENA DURING SUPERSONIC FLOW OF VISCOUS GAS IN CHANNEL WITH ELECTRICAL GLOW DISCHARGE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 10, No 15, 12 Aug 84 (manuscript received 3 Apr 84) pp 908-911

VOYNOVICH, P.A., DYMSHITS, B.M. and FURSENKO, A. A., Physical-Technical Institute imeni A.F. Joffe, USSR Academy of Sciences

[Abstract] The gas dynamic characteristics of a supersonic gas flow in the zone of a glow discharge is investigated. A laminar gas flow near the surface of the electrode in a channel is studied as an example. The growth of heat boundary layers and heating of gas in those layers reduce the useful volume of the discharge zone. It is found effective to evacuate the

boundary layers through the wall in order to prevent their growth and to circumvent heating of the gas near the electrodes. Distributed evacuation through the channel wall also helps to prevent turbulization in the channel. References 5: 4 Russian, 1 Western.  
[18-6900]

UDC 621.378.325

OCCURRENCE OF INVERSE POPULATION IN NON-STEADY-STATE EXPANSION WAVES FOLLOWING CUTOFF OF SUPERSONIC NOZZLE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 3, Jul 84  
(manuscript received 28 Nov 83) pp 600-603

GRIN', Yu.I., TESTOV, V.G., GOLUB, V.V. and NABOKO, I.M., Institute of Electrical Engineering and Electronics, USSR Academy of Sciences, Institute of High Temperatures, USSR Academy of Sciences

[Abstract] Variations in the inverse population and their relationship with variations in gas dynamic characteristics during non-steady-state flow through a nozzle are investigated by the shadow and interferometric methods. Zones are detected in which the sounding radiation is amplified due to unsteady expansion upward along the flow from the secondary wave, rather than shock heating of the escaping gas behind the front of that wave. The gain in this case may exceed the quasi-steady state value. References 5: 4 Russian, 1 Western.  
[17-6900]

UDC 519.6:532.59

NUMERICAL MODELING OF UNSTEADY PERIODIC VISCOUS FLOW IN THE WAKE OF A CYLINDER

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 24, No 8, Aug 84 (manuscript received 30 Dec 83) pp 1207-1216

BELOTSERKOVSKIY, O. M., BELOTSERKOVSKIY, S. O. and GUSHCHIN, V. A.

[Abstract] The flow of an incompressible viscous fluid about a right circular cylinder is investigated numerically. Unsteadiness is simulated by introducing instantaneous initial perturbations, or by exploiting the natural asymmetry of a stratified flow, making it possible to construct flows which are adequate to those observed experimentally. The method of splitting with respect to physical factors is employed, and is extended to the case of the flow of a liquid that is stratified in terms of density. The formation of internal waves is detected, as well as a classical Karman vortex street following the body. The experimental and theoretical findings



agree well, confirming the reliability of the method for studying flows with complex structures. The method can also be developed for solving problems in hydrophysics. Figures 9; references 12: 7 Russian, 5 Western. [451-6900]

UDC 532.593

POSSIBLE CAUSES FOR SPREAD IN EXPERIMENTAL CHARACTERISTICS OF DETONATION WAVES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 4, Aug 84  
(manuscript received 29 Jul 83) pp 845-847

ZUBAREV, V. N. and YEVSTIGNEYEV, A. A.

[Abstract] This study explains and validates the conclusions drawn by the authors in a previous analysis of detonation wave modeling. That paper stated that models can be only approximate when based on the assumption that the parameters of detonation wave front are fully characterized by constant parameters (such as the Jouget pressure, the chemical zone width, etc.) after the wave has traveled a finite distance. The use of approximate models to interpret the experimental data is the most probable cause for the difference in the experimental characteristics of detonation waves in condensed explosives. It is found that the closer the parameters of the front are to their asymptotic values, the more slowly the pressure gradients and velocities change in the region between the wave front and the acoustic plane. Figure 1; references 8: 5 Russian, 3 Western. [26-6900]

UDC 535.36:534.13

EXPERIMENTAL INVESTIGATION OF LIGHT SCATTERING ON SHAPE FLUCTUATIONS OF LIQUID DROPLETS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 8, Aug 84  
(manuscript received 23 Aug 83) pp 1599-1604

KALECHITS, V. I., NAKHUTIN, I. Ye. and POLUEKTOV, I. P.

[Abstract] Raman scattering of light on shape fluctuations of spherical liquid particles is investigated. The scattering of laser radiation on shape fluctuations of coagulating droplets and of droplets formed from a stream of liquid is investigated. Information is obtained on the hydrodynamic properties of the scattering process, which is of interest from the viewpoint of liquid mechanics, as well as a number of practical applications: the design and construction of liquid sprayers, monitoring the pressing of synthetic and glass fibers and metal wire from melts, etc. The method

makes it possible to calculate a priori the radius of the particles formed when producing monodisperse aerosols, and observing the parameters of the stream while experiments are under way. Figures 5; references 21: 16 Russian, 5 Western.  
[61-6900]

LASERS & MASERS

UDC 533.932

CHARACTERISTICS OF LASER EMISSION DISCHARGE CREATED BY PULSED CO<sub>2</sub>-LASER

Moscow FIZIKA PLAZMY in Russian Vol 10, No 4, Jul-Aug 84, (manuscript received 1 Jun 83 after revision) pp 757-761

BARKHUDAROV, E.M., GELASHVILI, G. V., GUMBERIDZE, G.G., RAZMADZE, D.I. and TAKTAKISHVILI, M.I., Institute of Physics, Georgian SSR Academy of Sciences

[Abstract] The parameters of a laser-emission discharge plasma ( $\lambda = 10.6 \mu\text{m}$ ,  $I = 10^{10} \text{ W/cm}^2$ ) and its characteristics as an emf source are investigated. The parameters of the plasma flame created by a pulsed CO<sub>2</sub>-laser are determined; the expansion rate, concentration and electron temperature during the initial and final stages of expansion are found. The basic characteristics of a laser-emission discharge as a emf source are measured: the amount of emf, the internal resistance and the efficiency, inter alia. It is shown possible to determine the electron temperature during the initial stage of expansion of a plasma flame from the voltage-current characteristic of the discharge. References 9: 5 Russian, 4 Western. [14-6900]

UDC 621.373.8

INITIATION OF H<sub>2</sub>+F<sub>2</sub>-LASER BY MULTI-PHOTON DISSOCIATION OF SODIUM HEXACHLORIDE

Moscow KHIMIYA VYSOKIKH ENERGIY in Russian Vol 18, No 5, Sep-Oct 84 (manuscript received 27 Jul 83) pp 456-460

KURDOGLYAN, M. S. and ORAYEVSKIY, A. N., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The dissociation of an SF<sub>6</sub> molecule caused by a brief powerful pulse from a CO<sub>2</sub> laser in the working mixture of an H<sub>2</sub>+F<sub>2</sub> laser is analyzed. The parameters (energy and duration) of the CO<sub>2</sub> laser pulse needed to obtain efficient conversion of the radiation energy of the CO<sub>2</sub> laser to HF-laser energy are determined. A model is developed for multi-photon dissociation

of  $\text{SF}_6$  in the working mixture of an  $\text{H}_2+\text{F}_2$  laser at atmospheric pressure. The influence of the composition of the mixture and some possibilities for improving conversion efficiency are discussed. Conversion efficiencies of approximately 500% can be expected when an  $\text{H}_2+\text{F}_2$  laser is initiated by a  $\text{CO}_2$  laser by  $\text{SF}_6$  multi-photon dissociation. References 14: 7 Russian, 7 Western.  
[64-6900]

UDC 533.6.011

INFLUENCE OF ADDED HYDROGEN AND XENON ON CHEMICAL COMPOSITION OF PLASMA OF WAVEGUIDE  $\text{CO}_2$  LASER

Moscow KHIMIYA VYSOKIKH ENERGIY in Russian Vol 18, No 5, Sep-Oct 84  
(manuscript received 5 Dec 83) pp 477-479

VOLCHENOK, V. I., KOMAROV, V. N. and OCHKIN, V. N., Scientific Research Physical-Chemical Institute imeni L. Ya. Karpov

[Abstract] Additives of xenon are employed in the laser mixtures of waveguide  $\text{CO}_2$  lasers, and hydrogen is employed in ordinary gas-discharge  $\text{CO}_2$  lasers to increase lasing power and the extend service life by acting upon the chemical composition of the plasma of the active medium. The influence of added xenon and helium on a  $\text{CO}_2+\text{N}_2+\text{He}$  (1:1.8) plasma is investigated. It is found that the addition of xenon does not change the chemical composition of the plasma significantly, but the addition of hydrogen does change it. The addition of 0.27 kPa hydrogen causes a drop in the degree of dissociation of molecular  $\text{CO}_2$  from 70% to 20%, and the concentration of molecular oxygen drops by an order of magnitude. This result would seem to agree with a theoretical model of low-pressure  $\text{CO}_2$  laser active media proposed earlier. References 6: 5 Russian, 1 Western.  
[64-6900]

UDC 621.373.8

THEORETICAL INVESTIGATION OF LASING IN  $4.3 \mu\text{m}$  REGION IN  $\text{CO}_2$  LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 46, No 3, Sep 84  
(manuscript received 10 May 83) pp 408-415

IVANENKO, M.M., TRUSHIN, S.A., CHURAKOV, V.V.

[Abstract] The limiting energy characteristics of a  $4.3\text{-}\mu\text{m}$  pulsed  $\text{CO}_2$  laser was investigated, and the conditions necessary for realizing them are determined. The influence of the various physical processes occurring in the active medium on the output parameters of the laser system is analyzed. The lasing process in a  $\text{CO}_2:\text{n}_2:\text{He}$  mixture pre-excited in an electrical

discharge is modeled numerically. It is found that maximum lasing power in energy is achieved when the pumping and lasing radiation is coupled through a common rotational sublevel. It is found analytically that radiation energy as high as 200 mJ/l can be obtained under actual experimental conditions. References 19: 10 Russian, 9 Western.  
[76-6900]

UDC 621.373.826

REDUCTION IN Q-FACTOR OF LASER CAVITY AS OPTICAL LENGTH BECOMES SHORTER

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 28, No 10 (manuscript received 29 Dec 83) pp 883-886

VOYTOVICH, A.P., OVSEYCHUK, S.I. and RUNETS, L.P., Institute of Physics, Belorussian SSR Academy of Sciences

[Abstract] Variation in lasing intensity as the result of the influence of scanning the optical length of the cavity on its Q-factor is investigated. The experiments were conducted with ruby, 6 Zy rhodamine and helium-neon lasers, all producing linearly polarized radiation. It is shown possible to achieve rates of change of the optical length of the cavity which reduce its Q-factor significantly, which is equivalent to the occurrence of additional losses (amounting to tens of per cent). This provides evidence that phase methods can be implemented for controlling laser parameters. References 2 Russian.  
[81-6900]

UDC 621.375.826

ACCEPTABLE HEAT LOADS OF NON-UNIFORMLY ILLUMINATED COOLED LASER MIRRORS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 47, No 2, Aug 84 (manuscript received 1 Mar 82) pp 314-319

KHARITONOV, V. V., GRISHUNIN, P. A., PLAKSEYEV, A. A. and TERYAYEV, V. V., Moscow Engineering-Physics Institute

[Abstract] The maximum thermal stresses, deformations and corresponding acceptable heat flow in cooled laser mirrors are found as a function of the degree of uniformity of illumination of the mirror and the amount of cooling. The influence of the relative size of the light spot on the deformation of the reflecting surface and on the maximum acceptable heat flows is analyzed. Figures 3; references 11: 7 Russian, 4 Western.  
[36-6900]



LASING IN  $\text{In}_{0.53}\text{Gd}_{0.47}\text{As}/\text{InP}$  LAYERS ( $\lambda = 1.53 \mu\text{m}$ ) SUBJECTED TO OPTICAL PUMPING

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 10, No 18, 26 Sep 84 (manuscript received 4 May 84 after revision) pp 1099-1102

KULYUK, L. L., RADAUTSAN, S.I., RUSSU, Ye.V., SMIRNOV, V.G. and STRUMBAN, E.Ye., Institute of Applied Physics, Moldavian SSR Academy of Sciences

[Abstract] Lasing in a  $\text{p-In}_{0.53}\text{Gd}_{0.47}\text{As}/\text{p-InP}$  structure subjected to optical pumping is reported. Epitaxial layers of a solid solution of indium-gallium arsenide were grown in a horizontal reactor and doped by adding zinc to the precipitation zone during the growth process. The specimens were excited optically by a pulsed  $\text{YAG:Nd}^{+3}$  laser ( $\lambda = 1.064 \mu\text{m}$ ), using both transverse and head-on pumping geometries. Recombination radiation was detected in the latter case from the excited surface in a direction close to its normal. The spontaneous luminescence spectrum is found to consist of two bands: one with a maximum at  $\lambda_{\text{max}} = 1.51 \mu\text{m}$ , and another with lower intensity at  $\lambda_{\text{max}} = 1.70 \mu\text{m}$ . Radiation emitted from the end of the layer was detected in the transverse excitation geometry. The findings suggest that  $\text{P-In}_{0.53}\text{Gd}_{0.47}\text{As}/\text{P-InP}$  layers are promising for use as optically end-pumped laser radiators. References 3: 1 Russian, 2 Western. [90-6900]

UDC 539.341

SUBMILLIMETER-BAND SOLID STATE DISTRIBUTED FEEDBACK LASER

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 19, No 4, Jul-Aug 84 (manuscript received 1 Apr 83) pp 198-205

ALEKSANYAN, A.G., BOYAKHCHYAN, G.P., MIRZABEKYAN, E.G. (deceased), Institute of Radio Physics and Electronics, Armenian SSR Academy of Sciences

[Abstract] The threshold characteristics of a solid state laser with anisotropic gain is analyzed. Allowance for anisotropy of the gain results in an asymmetric mode spectrum and a complex coupling coefficient that depends upon the thickness of the specimen, the permittivity of the active and passive media and the frequency of the acoustic wave. Resonant Bragg diffraction scattering is examined, assuming that the active medium, which is created by a magnetic field and an ultrasonic wave, is contained in a homogeneous dielectric medium with permittivity  $\epsilon_1$ . An acoustic wave with wave number  $k_0 = 2\pi/\Lambda$  propagating along the x axis caused the permittivity to change, thus facilitating distributed feedback. It is found, in contrast to the simple isotropic case, that the coefficient of absorption and the coupling coefficient change significantly: an effective index of refraction of the wave and an effective complex coupling coefficient occur which depend upon the thickness of the active region and the permittivities of the active and passive media. The threshold electron concentration is analyzed as a

function of the feedback coefficient, of temperature for the first four modes and of the specimen length. References 10: 8 Russian, 2 Western. [91-6900]

#### EXCITATION AND MAINTENANCE OF LONG SPARK BY RADIATION FROM FREE-RUNNING LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 54, No 9, Sep 84 (manuscript received 10 Aug 83) pp 1806-1808

GAVRILOV, V. M., GOLUB, S. L. and SKRIPKIN, A. M., Institute of Experimental Meteorology

[Abstract] This study reports the observation of a laser spark discharge as much as two meters long created by a free-running neodymium laser, as well as a solid optical discharge approximately 30 cm long resulting from the merging of individual long laser spark plasma centers caused by the influence of coaxial radiation from an auxiliary laser. The experimental setup employed is described. The occurrence of long laser sparking is a result of the significantly smaller radiation divergence due to the use of an unstable cavity, and the differing time structure of the pulse. It is found that no merging of individual sparks occurred when long laser sparks were initiated by radiation from a Q-modulated laser. Figures 2, references 7: 5 Russian, 2 Western. [94-6900]

UDC 621.375.826

#### WAVEGUIDE PHENOMENA IN DENSE RELAXING GASES AND THEIR USE IN CHEMICAL AND GAS-DYNAMIC LASERS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 54, No 9, Sep 84 (manuscript received 27 Oct 83) pp 1763-1771

BARMASHENKO, B. D., KOHELAP, V. A. and NAUMOV, V. V., Institute of Semiconductors, Ukrainian SSR Academy of Sciences

[Abstract] The possibility of forming radiation by exploiting the gasdynamic characteristics of flows within laser cavities is investigated. The periodic compression which occurs in flows can serve as gaseous dielectric waveguides which single out electromagnetic oscillations localized in narrow zones of inverse population. A shock wave in a chemically reacting  $H_2-F_2$  mixture and the flow of a dissociated diatomic gas about a body with a cooled surface are considered as examples. Localization and amplification of light in the boundary layer during radiation recombination reactions of atoms are analyzed. The examples indicate that the electromagnetic field distribution in laser cavities can be modified by exploiting various

gasdynamic characteristics of flows to achieve, inter alia, localization of the radiation in spatially narrow active layers. Figures 5, references 13: 11 Russian, 2 Western.  
[94-6900]

UDC 621.378.325

#### NEW HONEYCOMB NOZZLE MODULE FOR GASDYNAMIC LASERS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 9, Sep 84  
(manuscript received 9 Sep 83) pp 1824-1825

ACHASOV, O. V., BOREYSHO, A. S., BYKOV, A. M., LEBEDEV, V. F., MOROZOV, A. V., LABUDA, S. A., RAGOZIN, D. S., SOLOUKHIN, R. I. and FOMIN, N. A., Institute of Heat- and Mass-Exchange imeni A. V. Lykov, Belorussian SSR Academy of Sciences

[Abstract] The gain characteristics of a  $\text{CO}_2$  gasdynamic laser employing a honeycomb nozzle module are investigated experimentally. The nozzle module consists of a set of 48 axisymmetrical shaped nozzles with critical cross section of 1.1 mm and expansion factor of approximately 36. The investigations were performed on a shock-tube gas dynamic system. The gain of the active medium was recorded in four cross sections, at 25, 60, 160 and 260 mm beyond the cutoff of the honeycomb nozzle module. An ILCS-704 laser was employed, with nitrogen as the donor gas. The relationship between gain and nitrogen deceleration temperature, and between the gain of a weak signal and the pressure of the  $(\text{CO}_2 + \text{H}_2)$  mixture, are investigated. Figures 2, references 8: 2 Russian, 6 Western.  
[94-6900]

#### LASER R&D COOPERATION BETWEEN PHYSICS INSTITUTES

Minsk SOVETSKAYA BELORUSSIYA in Russian 23 Sep 84 p 2

[Article by R. Chenna]

[Text] An original laser unit which was developed and built in Vil'nyus has been turned over to the Belorussian Academy of Sciences' Physics Institute. Scientists will study complex organic molecules with this unit. Still another complex instrument is now being built to orders of Belorussian colleagues at the laser and electronic technology experimental plant of the Lithuanian Academy of Sciences' Physics Institute.

"The cooperation with the Belorussian physicists has been continuing for eight years, and this creative friendship is mutually advantageous for us," related Yurgis Vlaschakaa, director of the Physics Institute. "We have adopted many valuable things from the laboratories headed by N. Borisovich, president of the Belorussian Academy of Sciences, and Doctor of Physical-Technical Sciences A. Rubanov, a USSR State Prize laureate. They are working successfully in the field of dye lasers, for example. This work is useful also for specialists of our republic. Together with our Minsk colleagues, we are preparing joint publications and papers."

FTD/ENAF  
CSO: 1862/75

UDC 621373.825

**TWO-PHOTON MODULATION OF RADIATION FROM DISTRIBUTED FEEDBACK LASER**

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH I MATEMATICHESKIKH NAUK in Russian Vol 5. No 1, Jan-Feb 84 (manuscript received 5 Jul 83) pp 76-80

KARAMALIYEV, R.A. and DAO SUAN KHOY, Azerbaijan State University imeni S.N. Kirov

[Abstract] Two-photon modulation of the radiation from a distributed feedback dye laser is investigated theoretically. Light fluxes at the same frequency create a stationary periodic structure in the medium. The laser-frequency beams interfere within the active medium and produce a pumping-intensity traveling wave which causes two-photon modulation of the radiation. Irregular distribution of the pumping energy causes irregular heating of the active medium. It is found that two-photon modulation can be used to obtain pulses as short as  $10^{-9}$  seconds. References 11: 8 Western, 3 Russian. [20-6900]

UDC 621.373:535

**AMPLIFICATION OF SCATTERED INDUCED RADIATION FLUX IN HIGH-GAIN LASER RODS**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 6, Jun 84 (manuscript received 21 Jun 82) pp 1099-1103

SKOROBOGATOV, B.S. and USOSKIN, A. I.

[Abstract] The spatial distribution of induced radiation flux within a laser rod is determined through integrated investigations of the angular characteristics of the noisy induced radiation exiting the rod and the angular characteristics of the radiation scattering on its lateral surface. The measurements are made on neodymium-activated yttrium-aluminum garnet active elements in the form of a rod with a cylindrical surface and plane-parallel polished ends. Anti-reflection coatings were applied to the ends of the elements to reduce reflection to approximately 0.1%. It is demonstrated



that closed induced radiant fluxes for which lasing conditions are satisfied can form during strong scattering on the boundaries of the active medium. The stability of these fluxes depends strongly upon their orientation. The most stable fluxes are found to be those which scattered repeatedly at other than 'mirror' angles. The occurrence of a 'halo' of the induced radiation accompanying the occurrence of the generated mode is noted. References 7: 5 Russian, 2 Western.  
[21-6900]

## INDUSTRIAL LASER USE EXPANDING IN USSR

Moscow EKONOMICHESKAYA GAZETA in Russian, April 1983 No. 14, p 2

[Article by Ye. P. Velikhov, Vice President USSR Academy of Sciences "The Laser Beam is Working"]

[Text] The development of industrial procedures using lasers is convincing evidence of the significant effect of basic scientific discoveries on economics. The laser effect, which was predicted, discovered, and investigated with the decisive participation of Soviet scientists has, in a relatively short period--little more than two decades--passed through all stages of refinement and found wide-ranging application in the national economy.

In industry, one such application is laser thermal technology and also laser control of industrial processes. Lasers can be used effectively in large-scale chemical production. They show great promise in such fields as biology, environmental protection, construction and irrigation works, communications, computer technology, printing, and image recording and processing. Lasers serve as one of the means of solving the problem of a controlled thermonuclear reaction.

In the 11th Five Year Plan, a target complex scientific-technical program called "Creation and Production of Laser Techniques for the National Economy" is being implemented. Studies are being performed along the following main lines:

- Development and construction of laser with output power greater than one kilowatt for industrial applications;

- Organization of testing departments and laboratories in pilot industrial plants and leading research institutes of the various branches of industry for the purpose of devising and adopting laser industrial processes;

- The formation of an industrial base for large-scale mass production of lasers and industrial laser devices;

- The development and organization of the mass production of industrial laser installations;

-Maintaining the mass production of different types of lasers with power less than a kilowatt and laser equipment for all possible applications in the national economy;

-Occupational safety procedures for work with laser emissions.

More than twenty ministries and institutions and more than one hundred executive organizations are participating in the program. The USSR Academy of Sciences, Minelektrotekhprom [Ministry of Electronics Technology Industry] and Minstankopromy [Ministry of Instrumentation Industry] are chief among its implementers.

#### Effect of the New Technology

Gas lasers with power greater than one kilowatt are the most promising for metalworking and machine building. Lasers of this size are used for cutting, welding, heat treatment, hardfacing, and alloying metals. This field of application promises to become the largest. It is already clear now that laser technology is more than twice as profitable, in terms of the basic process indicators, and it permits basically new operations to be performed.

A common feature of all laser thermal industrial processes is their high productivity and the high rate at which equipment expenditures are recovered. Despite the relatively low efficiency (about 10% for existing laser equipment), in the final account energy costs are saved because of the better quality of workmanship.

A comparison of laser and argon-arc welding methods which require approximately the same amounts of energy per unit seam length has shown that as a result of the lengthened service life of the parts welded by laser, their production volume is reduced. In other words, the total energy material costs are lowered. At the same time, it should be borne in mind that the implementation of laser technology results not only in technical and economic advantages but also social benefits: an improved work environment, reduced expenditures for manual labor, and healthier working conditions.

Laser metalcutting is performed at emitted power densities of  $10^5$ - $10^7$  watts per square centimeter, sufficient to melt and vaporize the material. The rate is 15-40 meters per minute and the cut width from 0.2 to 0.05 mm. Three to five times less material is wasted than by other methods. It is possible to cut out articles of intricate shape with an accuracy in the hundredths of a millimeter. Lasers permit the cutting of patterns in refractory metals, ceramics, fabrics, plastics, wood, composite materials, anything that may be desired. The process is so rapid that the surface does not have time to heat up substantially, the properties of the materials in the zone of the cut are practically unaltered, and the parts are not deformed due to residual stresses.

There is no longer a need for expensive and rapidly wearing cutting tools of superhard materials. The high quality of the workmanship dispenses with the need for the secondary processing of parts. Thus, laser cutting is highly

efficient in shipbuilding, aviation, electrical engineering, and in other branches of industry for pattern cutting, punching holes, cutting depressions and the marking of parts. Up to 70% of the cutting costs are saved. The equipment pays for itself in about one year.

A power density of  $10^5$ - $10^6$  watts per square centimeter is required for laser welding. The thickness of the items being worked in this case amounts to about one millimeter per kilowatt of laser radiation. Welding speeds ranging from 0.3 to 2 meters per minute are assured. The thermal effect zone is so small that the parts being welded are in no danger of any appreciable deformation whatsoever. Very strong joints are produced. In addition, it is possible to combine different types of materials. Laser welding is not inferior in quality to electronic arc welding and does not require the vacuuming of the parts, in contrast to the latter method.

Laser hardfacing of resistive materials is highly effective. This permits a two- to threefold increase in the service life of the parts under conditions of high mechanical loads. Consequently, the production volume of spare parts can be reduced by the same factor. Similar benefits are derived from restoring worn-out parts of motors and mechanisms. Laser hardfacing differs from other hardfacing methods in its high accuracy, speed, and productivity.

Thermal hardening is the most widely used of the laser metalworking processes. At power densities of  $10^4$ - $10^5$  watts per square centimeter, the radiation rapidly heats the surface of the parts to a temperature close to the melting point. Upon rapid cooling as a result of heat removal, a peculiar type of "tempering" occurs on the surface layer of metal, its structure becoming finely divided and even amorphous. This greatly increases the hardness and wear resistance.

A shining example of the effectiveness of this type of machining may be provided by the evaluation of the laser thermal hardening process of the cylinder block of the ZIL-130 automobile engine, a process now being adopted in the AvtoZIL complex. According to calculations, about two million rubles will be saved per year. Laser thermal hardening may be widely used in motor-building, machine tool, and other branches of industry.

The property of lasers of emitting light in a very narrow range of wavelengths is exploited in selective technology.

It is well known that molecules and atoms in the gaseous state absorb radiation only in narrow spectral intervals. At the same time, these bands differ from one another for different substances. It is possible to select the wavelength of the laser emission in such a way that it will be received by only one kind of molecule, the kind desired. The emission energy of lasers is sufficient not only to heat up but also to dissociate the molecules and to ionize the atoms.

By removing the fragments of dissociated molecules or ionized atoms from the irradiated space, e.g., with an electrical field, it is possible to purify a substance. This method, which permits fundamentally new chemical processes to be performed, is already in use in laboratory research.

At present the laser enrichment and separation of isotopes, laser purifications of materials by selective ionization, laser chemical synthesis, and laser photochemistry, are lines of development determining not only the future program of scientific research but also the real process of laser use in the plants of the chemical industry. The selective action of laser radiation on molecules can be employed effectively in biology and medicine. Laser methods of phototherapy are currently under active investigation.

#### The Road to Production

The directive issued by the 26th Party congress for the integration of science and industrial production has also determined the approach to the solution of the problem of the implementation of laser technology. At GKNT [expansion unknown] and the Presidium of the USSR Academy of Sciences, an inter-institutional scientific-technical advisory board has been established which has united the leading specialists in the field. The activity of its eight sections encompasses both the design of industrial lasers, instruments, and installations based on them, as well as implementational, purely production-related problems.

The USSR Academy of Sciences (AS USSR) operates the Scientific Research Center for Technological Lasers (SRCTLAS). Its basic assignments include not only the development of laser installations and methods but also their adoption in industry. The center has base laboratories at the Likhachev automobile plant and in other machine-building enterprises where scientists and producers jointly decide on specific technological operations to be performed with the aid of high-power lasers. As practice has shown, this is the most efficient way of transferring scientific developments to industry.

The training of personnel occupies a special position. In particular, a scientific training center in laser technology has been established by the USSR Academy of Sciences and the USSR Ministry of Higher Education on the basis of SRCTLAS and the Moscow Higher Technical School imeni N.E. Bauman, where training in new specialties is conducted.

The 1981-82 goal of a target complex program has basically been fulfilled. The lasers developed with powers from 1 to 5 kilowatts were transferred by the scientists to the Minelektrotekhprom for the organization of mass production of industrial installations.

These include the 1.2 kilowatt LOK-2M laser constructed at the Institute for Theoretical and Applied Mechanics of the Siberian Branch of the AS USSR, the Lantan laser with a power up to 2 kilowatts built by the Institute for Problems in Mechanics of the AS USSR, and the 5 kilowatt TL-5 laser developed by SRCTLAS, as well as many others.



Mass production has been increased, and the scale of adoption by industry of solid state, gas, and semiconductor lasers and laser-based devices with less than a kilowatt of power has expanded. In public health care, already mass-produced laser instruments are in use instead of custom made experimental models: in surgery the Skal'pel' and Romashka-1, in eye microsurgery the Yatagan, the Oka-2 in ophthalmology, the Razbor in oncology, and the Yagoda in therapy.

The Institute of Spectroscopy of AS USSR, the Institute for Atomic Energy imeni Kurchatov, SRCTLAS, and other organizations have obtained good results in gas physics research as well as in the discovery of theoretical and experimental principles of selective laser atomic-molecular technology. Research and development is being conducted on the application of lasers in instrument building, the production of monitoring-measuring devices, information processing systems and spectral devices.

After two years of working on the target complex program, we have come noticeably closer to the widespread adoption of laser technology in industry and have identified the basic organizational problems. Nevertheless we are not satisfied with what has been achieved. Significantly more can and should be done. The mass production of industrial lasers and special equipment for laser processing has, unfortunately, not yet reached the necessary level.

#### Problems of Implementation

The path from an idea to its concrete practical fruition is covered most rapidly wherever there is unity of the scientific, engineering, and production forces. This is confirmed by the activities of a large number of scientific-industrial organizations. During the introduction of a new inter-industrial technologies which arise on the basis of fundamental research, such associations, in our view, should be established on the base of the leading inter-branch scientific institutions such as the institutes of the AS USSR usually are. The evidence of this is the experience of the Institute for Electric Welding imeni Paton of the UkSSR Academy of Sciences and the Siberian Branch of the AS USSR. SRCTLAS has been called upon to become such a target interbranch research-industrial base. However, its capacities are not developing at a sufficient pace.

Laser equipment is made up of complicated systems whose manufacture must be carried out by producers of different profiles. The corresponding directives have been submitted to the executive ministries. However, the work on the creation of the specialized components, materials and equipment is moving slowly at the Minkhimprom [Ministry of Chemical Industry], Minkhimmash [Ministry of Chemical Machinery Manufacture], Minelektrotekhprom, and Gosstandard [State Bureau of Standards]. They have not even been begun at the Minstankoprom and Minpribor [Ministry of Device Manufacture]. The problem of supplying optics for mass produced laser installations has also not been resolved organizationally.

Since the Minelektrotekhprom is not fully satisfying the demand for lasers, the consumer branches themselves are beginning to make the necessary

equipment. For instance, Minsudprom [Ministry of Shipbuilding Industry] manufactures several variants of the installations for its own needs.

The inter-industrial character of the science-intensive laser technology also necessitates optimal forms of adoption. Rather extensive physical knowledge in the field of lasers, measurement methods, and the principles of interaction of laser radiation with materials is required in order to set up a specific technological process under factory bench test conditions. These circumstances have made it necessary to establish base laboratories and testing facilities for the adoption of laser technology in pilot plants of the various branches of industry and in the leading branch institutes with the direct participation of the AS USSR organizations.

The process of laser metalworking are, in many ways, universal and of the same type for the various branches of machine building. Therefore it is advisable to establish interbranch regional centers for research on the application of laser technology and to fill one-time orders for laser processing. Later they will be able to grow into specialized enterprises.

If we spoke earlier only of the profits to be gained with lasers in the various technological processes, we now must speak of speeding up operations on the construction of flexibly retoolable production lines making use of lasers. The laser, being an extremely productive and universal instrument, is most efficiently utilized when there are no interruptions and power losses during preparatory operations. The installation should be able to service several industrial stations in rapid sequence, each of which operates as a part of a specific line. Then the advantages of laser equipment may increase ten-fold. We are speaking of the construction of "integrated", automated, and robotized laser-industrial systems, workshops, and plants. This is one of the promising lines of development of operations according to the target program.

The 11th Five Year Plan is an important step in the adoption of laser techniques and technology in the national economy. Many of the advantages which they bring are already being exploited in practice, but it may be stated with confidence that the main achievements still lie ahead.

12822

CSO: 8144/0017

UDC 621.373:535

## MODE LOCKING IN RING LASERS WITH NONLINEAR ABSORBER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84  
(manuscript received 4 Oct 82) pp 110-116

LANDA, P. S. and MOYISEYEV, V. N.

[Abstract] The problem of mode locking in a traveling-wave laser with a nonlinear absorber is solved analytically on the basis of semiclassical equations by the Bubnov-Galerkin method. The regions of instability of single-mode emission are defined as a function of the parameters of the amplifier and absorber. The amplitude and duration of the pulses generated in the mode-locking condition are found. When the coefficient of absorption approaches zero, the findings agree with those obtained for mode self-locking in a laser not employing an absorber. References 15: 7 Russian, 8 Western.  
[38-6900]

UDC 621.373:535.01

## SELF-CONSISTENT METHOD FOR DESIGNING LASER PUMPING SYSTEMS. CHARACTERISTICS OF PUMPING SYSTEMS WITH INHOMOGENEOUS TEMPERATURE DISTRIBUTION IN LAMP DISCHARGE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84 (manuscript received 14 Jul 81) pp 105-109

GRADOV, V. M., MAK, A. A., SHCHERBAKOV, A. A. and YAKOVLEV, A. V.

[Abstract] A self-consistent analytical method described in another study is employed to investigate the characteristics of optical pumping systems employed in circular single-unit lasers. The effectiveness of mercury- and xenon-filled lamps is compared. The influence of the pumping system on the temperature distribution in the discharges, the spectral characteristics of the lamps, their electrical parameters and the energy balance is investigated. The method, and the software developed on its basis for computer-aided design of optimal laser pumping systems makes it possible to obtain

the necessary initial information for calculating the emission characteristics of the laser radiator as a whole and for investigating the temperature and stress/strain state of its elements. References 10: 8 Russian, 2 Western.  
[38-6900]

UDC 621.373:535

INVESTIGATION OF LASER CHARACTERISTICS OF WATER-SOLUBLE DYES FOR BLUE-GREEN REGION OF EMISSION SPECTRUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84 (manuscript received 18 Feb 83) pp 95-98

DZYUBENKO, M. I., KRAYNOV, I. P. and MASLOV, V. V.

[Abstract] Emission characteristics of oxazole pyridine halides of the type  $(\text{PhOPy-R})^+\text{X}^-$ , where  $\text{X}=\text{Br}, \text{Cl}$  are investigated for different pumping durations. The compounds were synthesized in order to find photostable water-soluble laser dyes for the blue-green region of the spectrum. The absorption spectra were measured on a VSU-2-P spectrophotometer; and MDR-2 photoelectric monochromator was employed to measure luminescence. The energy stability of the emission of these compounds is found to be better than that of existing water-soluble compounds when flashlamp pumping is used. Induced reversible absorption is found to exert a harmful effect for pumping durations exceeding 1 microsecond. The oxazole pyridine derivative halides examined are promising for use in narrowband tunable lasers with long service life. However, when pumping pulses exceeding 1 microsecond are employed, the influence of triplet absorption must be reduced, e.g., by synthesizing a system with intramolecular quenching of the triplet state. Reference 4: 2 Russian, 2 Western.  
[38-6900]

STATE PRIZE NOMINATION FOR WORK ON PARAMETRIC TUNABLE LASERS

Vilnius SOVETSKAYA LITVA., 21 October 84 p 4

[Chesna, R.]

[Excerpt] Specialists of the laser research center of Vil'nyus University have developed parametric tunable lasers which are distinguished by high output power and supershort pulse duration.

We were in a laboratory of this center, where the country's first femto-second laser complex with a wide tuning range has been installed. A sophisticated experiment for the study of high-speed photosynthesis processes was in progress.

"Highly complex intra-atomic and intramolecular processes take place in segments of time that are measured in exceptionally small amounts," remarked Doctor of Physical-Mathematical Sciences Al'gis Piskarskas, director of the center. "Only the development of these parametric lasers has made such studies possible."

A. Piskarskas and his colleagues--senior science associates A. Yuozapavichyus and R. Danelyus--showed me a small transparent crystal. It transforms laser radiation into all the colors of the rainbow. Whereas such changes in color used to be effected by dozens of dyes and required costly optical components and intricate mechanical assemblies, this is now done by a single crystal. Incidentally, this crystal also permits the generation of substantially more powerful radiation.

Principles of highly efficient parametric transformation of laser radiation that were developed in Vil'nyus and wide-range tunable lasers which have been designed on this basis have opened up prospects for utilizing quantum generators both in basic research and in the economy. The penetrating ray is already operating in optical-fiber communications systems which increase the volume and speed of information transmission by several hundred times. The new lasers will also aid the development of optical computers whose performance surpasses that of conventional ones by 1,000 times.

The university physicists' research is part of a cycle which has been nominated for the 1984 USSR State Prize. Al'gis Piskarskas is one of the candidates for this prize award, together with eminent Soviet scientists.



## INDUSTRIAL LASERS CENTER'S RESEARCH ROLE, EXPANSION PLANS

Moscow, LENINSKOYE ZNANIYA, 2 October 84 p. 2

[PANKOV, A., correspondent interviewer]

[Abstract] In an interview, Candidate of Technical Sciences Galym Abil'sitovich Abil'sitov, director of the USSR Academy of Sciences' Industrial Lasers Scientific Research Center, comments on the R&D role of this center and on plans for the expansion of its facilities. The center was organized a few years ago in the Moscow suburb of Troitsk. It is to become a coordinator of the work of industry institutes in various directions of laser development, according to Abil'sitov. He mentions in this connection that the center hosted an all-Union seminar on laser technology, and that the first all-Union conference on the use of lasers in machine building was held here.

Abil'sitov calls the center an academy institution with organizational features of a modern research and production association (NPO). As an academy institution, it pursues basic research and explores possibilities for the advancement of new directions that are discovered in this connection. However, the center has the task of developing not only lasers themselves but also industrial equipment and production processes in which all operations are automated. Thus, the center will eventually comprise an experimental production facility in addition to research and design sections. Ideas of the center's personnel can thus be elaborated and find embodiment in production prototypes of lasers. Unlike a conventional NPO, the center has no specific production obligations to industry. Abil'sitov explains, its task is simply to produce prototypes of laser technology that are capable of operating in industrial conditions. Abil'sitov says the decision was made to focus effort initially on the introduction of those types of lasers which were best developed and whose characteristics meet the requirements of industry best. Three basic types were thus selected. Work on the development of lasers for medicine and communications is also expected to be done at the center in the future.

With regard to the center's growth plans, Abil'sitov mentions that a number of sectors are to be created in its design bureau, including an optical components sector, and he comments in some detail on plans for a laboratory-and-production facility which the center is building in the Moscow suburb of Shatura. The first phase of this facility is scheduled for completion

at the end of this year, and all of its main buildings are to be completed in two or three years. The facility's laboratory buildings will house five testing units to begin with. Among them will be two automated laser production complexes specialized for precision cutting of sheet materials and for heat hardening of parts, and a third specialized unit which will be used in the development of methods for laser welding of body parts. The fourth unit will be used in investigating new methods for the industrial application of lasers, and the fifth will be used in purely physical directions of research, including studies of gas-discharge laser pumping methods.

A multipurpose complex consisting of 15-20 testing units is eventually to be created at the laboratory facility. These units will be used for work in promising directions, such as research of atomic-and-molecular laser technology which would allow effects to be produced selectively on individual atoms and molecules. The development of an industrial unit for laser synthesis of chemical compounds has also been proposed at the facility.

FTU/SNAP

CSO: 1862/127

LOW-THRESHOLD InGaAsP/InP HETEROSTRIP CONTINUOUS LASERS ( $\lambda = 1.3 \mu\text{m}$ )

Leningrad FIS'NA V JURNAL TEKHNIЧЕСКОГО ФИЗИКИ in Russian Vol 10, No 16,  
26 Aug 84 (manuscript received 17 Apr 84) pp 961-964

ALFEROV, Zh. I., GATSOV, E. A., GORELENKO, A. T., IL'INSKAYA, N. D. and  
VARASOV, I. B., Physical-Technical Institute imeni A. F. Joffe, USSR  
Academy of Sciences

[Abstract] A simple technique is demonstrated for producing single-mode continuous low-threshold InGaAsP/InP heterostrip heterolasers. InGaAsP/InP dual laser heterostructures were created by liquid-phase epitaxy on InP<sub>0.99</sub>As<sub>0.01</sub> substrates. The heterostructure consisted of four layers: a buffer layer of n-InP<sub>0.99</sub>As<sub>0.01</sub> approximately 5  $\mu\text{m}$  thick, an undoped narrowband active region of InGaAsP approximately 0.3  $\mu\text{m}$  thick, an intermediate undoped layer of n-InP approximately 0.3  $\mu\text{m}$  thick to prevent acceptors from entering the active region, and a p-InP layer approximately 1  $\mu\text{m}$  thick. The spectral composition of the radiation, the watt-ampere characteristics, the near and far radiation fields and temperature behavior of the threshold current were investigated. The distribution pattern of the radiation intensity in the near and far field indicates that these lasers practically have only a single fundamental transverse mode. The divergence of the radiation in the plane parallel to the heteroboundary plane was 15-20°, and 50° in the perpendicular plane. The threshold current was found to vary exponentially, with a discontinuity at 310K. Figures 2; references 3; 2 Russian, 1 Western.  
[60-8900]

SUPERSONIC CO-LASER WITH STATIONARY OXYGEN SOURCE BASED ON  $\text{C}_2\text{H}_2/\text{O}_2$  FLAME

Leningrad FIS'NA V JURNAL TEKHNIЧЕСКОГО ФИЗИКИ in Russian Vol 10, No 16,  
26 Aug 84 (manuscript received 7 Feb 84) pp 972-975

BUKIS, V. A. and OCHERKINSON, V. A., Institute of Problems of Mechanics,  
USSR Academy of Sciences

[Abstract] A chemical source of stationary oxygen based on combustion of a  $\text{C}_2\text{H}_2\text{-O}_2$  mixture in a supersonic CO-laser is investigated. The experimental installation consisted of a burner, a distribution unit and a resonator

unit. Carbon disulfide vapors were injected through 4 1-mm holes from the cylindrical surface of the injector. After the  $\text{CS}_2\text{-O}_2$  mixture was ignited, the flame was stabilized on the end of the injector, from which it propagated over the entire cross section of the quartz tube. Radiated power of 1-1.2 W was obtained; the lasing spectrum was recorded, making it possible to find the number of vibrational transitions participating in the lasing. The lasing band was found to be no narrower than the spectra of other supersonic lasers, indicating little influence on the part of the CO which flows together with the atomic oxygen from the source. The results indicate that a  $\text{CS}_2/\text{O}_2$  flame is sufficient as an atomic oxygen source to create the active medium for a supersonic chemical CO laser. Figure 1; references 4: 1 Russian, 3 Western.  
[60-6900]

UDC: 621.373:535

**DIFFRACTION NONRECIPROCITY OF COUNTER PROPAGATING WAVE GENERATION IN RING LASER WITH WEAK DIFFRACTION**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 2, Aug 84 pp 328-334

GLUSHCHENKO, Yu. V., RADINA, T. V. and FRADKIN, E. Ye.

[Abstract] The diffraction non-reciprocity of the generation of fundamental-mode counter-propagating waves during weak diffraction on an aperture with Gaussian transmission distribution is investigated within the framework of perturbation theory. The general case of a ring laser consisting of an arbitrary number of spherical mirrors is considered. Simple estimates are obtained for the diffraction frequency difference and for the difference in the intensities of the counter-propagating waves, which are expressed through physically clear parameters - the half-width and curvature of the wave fronts of the Gaussian beams. A simple expression is found for the functionals which define the diffraction difference of the frequencies and intensities of fundamental-mode counter-propagating waves. It is shown that the diffraction frequency differs for weak diffraction and a short active medium is proportional to the product of a diffraction correction to the half-width of the Gaussian beam and to the curvature of the wavefronts of the intrinsic oscillation unperturbed by the fraction. References 7: 6 Russian, 1 Western.  
[66-6900]

UDC 621.373:535

MECHANISM OF LOW FREQUENCY OUTPUT POWER FLUCTUATIONS OF GAS-DISCHARGE LASERS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 2, Aug 84  
(manuscript received 19 Jan 83) pp 319-324

MELEKHIN, G. V., STEPANOV, V. A. and CHIRKIN, M. V.

[Abstract] A method is developed for describing the fluctuations in the output power of a laser caused by the random nature of the electron excitement of the atoms (including ionization). The noise of an HeCd cataphoresis laser is examined as an example of the use of the approach. It is found that plasma instability is transferred to the radiation of the He-Cd laser by direct modulation of the density of the excited cadmium ions, rather than by direct modulation of the discharge current. References 8: 7 Russian, 1 Western.  
[66-6900]

UDC 621.373:535(206.3)

MODE INTERACTION IN MULTIFREQUENCY GAS RING LASER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 2, Aug 84  
(manuscript received 4 Nov 82) pp 325-327

KIRIYEVSKIY, A. P., NIKONCHUK, M. O. and PUGACH, I. P.

[Abstract] Wave competition in a Zeman ring laser is investigated in two operating modes - free lasing and longitudinal mode locking. The amplitude-frequency characteristics of electrical current sensors based on multi-frequency ring lasers can be found by investigating the phenomena occurring in such a laser. A helium-neon laser with a near-isotropic cavity 15 meters long was investigated. Gradual variation in the modulation percentage is found to cause a redistribution of the intensities between the lasing modes, with a consequential change in the influence of the persistence of each of the modes on the position of the mode spectrum with respect to the amplification line. References 6 Russian.  
[66-6900]



UDC 621.373:535

INFLUENCE OF APERTURE MISALIGNMENT ON NON-RECIPROCITY OF COUNTER-PROPAGATING WAVES IN RING LASER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 2, Aug 84  
pp 270-274

BOYTSOV, V. F.

[Abstract] The difference in frequency and power i.e., non-reciprocity of counter-propagating waves in a gas ring laser caused by misalignment of an aperture with a Gaussian transmission factor is found. The influence of misalignment on the non-reciprocal properties of counter-propagating waves in laser with flat mirrors is compared with that of lasers with spherical lasers. The functions which define the non-reciprocity of the emission frequencies of the counter-propagating waves differ from one another only in the cavity factors. The functions which determine the relative difference in the lasing power of the counter propagating waves are  $N$  times smaller for a laser with a spherical mirror than for one with flat mirrors, where  $N=ka^2/L$ ,  $K$  is the wave number,  $a$  the effective aperture radius, and  $L$  the axial length of the resonator. References 6 Russian. [66-6900]

SELF-DEFOCUSING OF CONVERGING LASER BEAMS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 87, No 3 (9), Sep 84 (manuscript received 28 Dec 83) pp 730-741

DANILEYKO, Yu.K., DECTYAREV, L.M., KOPA-OVDIYENKO, A.L., and LEBEDEVA, T.P., Institute of General Physics, USSR Academy of Sciences

[Abstract] The self-defocusing of sharply-focussed laser beams in the region where they interact was investigated. The investigations describe thermal defocusing and defocusing caused by free charge carriers generated during multi-photon optical ionization. Steady-state and non-steady-state self-defocusing are considered for different types of nonlinearity of the medium. The influence of nonlinear absorption on the nature of the process is determined for the steady-state case. It is found that the maximum change in the permittivity of the medium is independent of the frequency of the incident radiation, and is determined by the square of the focusing angle. It is found that self-defocusing of tightly focused beams results in broadening of the beam and a reduction of the intensity in the focal region. The domain of the non-aberration approximation for solving this class of problems is defined by comparing the results of the numerical calculation and the solution in the non-aberration approximation. References 14: 13 Russian, 1 Western. [69-6900]

MOLECULAR PHYSICS

UDC 533.15

QUANTUM-MECHANICAL CALCULATION OF DIFFUSION COEFFICIENTS OF METAL VAPORS  
IN GASES

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 47, No 4, Oct 84  
(manuscript received 11 Jul 83) pp 608-617

AREF'YEV, K. M. and GUSEVA, M. A., Leningrad Polytechnical Institute imeni  
M. I. Kalinin

[Abstract] The diffusion coefficients of alkali metal vapors in inert gases are calculated using nonempirical and semi-empirical quantum mechanical predictions for the potential energy of atomic interaction. The nonempirical calculations are performed by the Hartree-Fock self-consistent field method, in which the molecular orbitals are defined by linear combination of atomic orbitals with Gaussian or Slater-type basis functions. The semi-empirical quantum mechanical calculations are performed by the variation method with various simplifications to the Hamiltonian of the Schrödinger equation. The diffusion coefficients of two-electron metal vapors in helium, argon and neon are calculated. The predicted diffusion coefficients agree well with the experimental findings. Figures 3, references 27: 14 Russian, 13 Western.  
[99-6900]

UDC 621.378:383:547.826

DISSOCIATION OF POLYATOMIC MOLECULES CAUSED BY IR LASER RADIATION (A REVIEW)

Moscow KHIMIYA VYSOKIKH ENERGIY in Russian Vol 18, No 5, Sep-Oct 84  
(manuscript received 1 Nov 83) pp 387-411

TRAKHTENBERG, L. I. and MILIKH, G. M., Scientific Research Physical-Chemical  
Institute imeni L. Ya. Karpov

[Abstract] The current picture of the phenomena occurring during laser-induced dissociation of a gas consisting of polyatomic molecules is described. The physical and chemical effects dealt with in the literature are viewed

without reference to individual measurement methods. The following areas are reviewed: collisionless laser-induced dissociation; influence of collisions on laser induced dissociations; selectivity of laser-induced dissociation; the influence of competing chemical reactions on dissociation product yield; initiation of chemical reactions with the help of laser-induced dissociation products; and the dissociation of molecules caused by quasicontinuous IR laser radiation. References 164: 58 Russian, 106 Western. [64-6900]

UDC 666.11:543

#### DETERMINATION OF $P_2O_5$ IN PHOSPHATE-SILICATE GLASSES

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA in Russian Vol 16, No 3, Aug 84 (manuscript received 16 Jun 83) pp 118-120

KAMENTSEV, Ya.S. and GORNOVSKAYA, N. K.

[Abstract] The determination of phosphorous pentoxide in phosphate-silicate glasses of complex composition is examined. The amount of phosphorous is determined by volumetric alkalimetric determination of phosphoric acid following ion-exchange extraction from the cation components of the sample. The equivalence point is found by the potentiometric method, which provides the best analytical accuracy, and also makes it possible to automate the titration process and to record the titration curve objectively. The results provided by the proposed method are tabulated, indicating good accuracy and reliability. References 6 Russian. [95-6900]

UDC 621.373.826

#### LASER-INITIATED PHASE TRANSITION IN CHEMICALLY ACTIVE MEDIUM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 6, Aug 84 (manuscript received 9 Jan 84) pp 1357-1361

BUNKIN, F. V., corresponding member, USSR Academy of Sciences and KIRICHENKO, N. A., Institute of General Physics, USSR Academy of Sciences

[Abstract] The response of chemically active media to heat caused by laser radiation is investigated. It is shown that in media with reversible reactions thermodiffusion phenomena can cause laser radiation to induce a phase transition which is accompanied by the occurrence of a steady-state spatially inhomogeneous structure (with periodically varying temperature and concentration of the component). The mechanism underlying the formation of the dissipative structures are important for understanding the processes involved in the interaction between radiation and matter. Figure 1; references: 9 Russian. [37-6900]

UDC 535.211

IRON ALLOYING BY CARBON DURING GAS BREAKDOWN AT ATMOSPHERIC PRESSURE BY  
RADIATION FROM PULSE-PERIODIC CO<sub>2</sub> LASER

Moscow POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA in Russian No 9, Sep 84  
(manuscript received 30 Nov 83) pp 119-126

ANISIMOV, V. N., BARANOV, V. Yu., BOL'SHOV, L. A., IL'IN, A. I.,  
KOPETSKIY, Ch. V., KRAPOSHIN, V. S., MALYUTA, D. D., MATVEYEVA, L. A.,  
PIS'MENNYI, V. D. and SEBRANT, A. Yu.

[Abstract] The impregnation of carbon in surface layers of low-carbon steel during the formation of a low-threshold surface optical breakdown plasma produced by a pulse-periodic CO<sub>2</sub> laser in gas at atmospheric pressure is investigated. The specimens were irradiated with pulse-periodic CO<sub>2</sub> laser with average power of up to 1.5 kW and a maximum pulse repetition frequency of 1.2 KHz. The pulse energy ranged from 1 to 2 J, and the total pulse duration varied from 0.5 to 5  $\mu$ sec. Industrial-grade propane was used as a gas-donor of carbon. Layers on the order of 10  $\mu$ m thick were produced; it is found that modern periodic pulsed lasers can be used to treat surfaces in this way at rates ranging from 1 to 10 cm<sup>2</sup> per minute. A qualitative model is proposed for the process by which these layers are obtained which makes allowance for the phenomena occurring in the surface breakdown plasma and within the layer of molten metal. Figures 3; references 14: 13 Russian, 1 Western.

[24-6900]

UDC 539.04

CHARACTERISTICS OF LASER HEATING OF METAL IN OXIDIZING ATMOSPHERE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 6, Aug 84  
(manuscript received 26 Aug 83) pp 1395-1399

RYKALIN, N. N., academician, UGLOV, A. A., SMUROV, I. Yu. and VOLKOV, A. A.,  
Institute of Metallurgy imeni A. A. Baykov, USSR Academy of Sciences

[Abstract] This study examines the nonlinear non-steady-state spatial problem of heating of a semi-infinite body by a CO<sub>2</sub> laser considering the growth of the oxide film and the resulting change in absorbing capacity. It is found that the heating of metal by continuous radiation from a CO<sub>2</sub> laser in an oxidizing atmosphere stimulates the development of a surface oxide film whose growth rate depends strongly upon the flux density of the incident radiation; the absorbing capacity of the oxide + metal system increases sharply, resulting in an increase in the heating rate, followed by increased thickness of the oxide film, etc. The occurrence of an oxidation reaction on the surface results in a characteristic heating mode depending upon the strength of the incident radiation. The analytical



solution obtained supports a qualitative description of all of the characteristic metal heating modes in an oxidizing atmosphere which have been observed experimentally. Figures 4; references 10: 9 Russian, 1 Western.  
[37-6900]

UDC 535.333

SPECTRAL-PHASE EFFECTS AND SELECTIVE DETECTION OF COMPOUNDS BASED ON EXAMPLE OF IODINE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 7, Jul 84  
(manuscript received 20 Aug 83) pp 1392-1394

GANEYEV, A.A., NOVIKOV, V.A. and TURKIN, Yu. I., Leningrad State University imeni A. A. Zhdanov.

[Abstract] The use of the spectral-phase effect in a nonresonant transition  $7s^3 S_1 - 6p^3 P_2$  (green line  $\lambda = 546.07$  nm) of mercury to find the concentration of molecular iodine in air is described. Comparison of interferograms taken with and without modulation demonstrate a redistribution of the relative intensities of the components. An experiment is described in which a substance is placed in the path of the light beam which selectively absorbs one of the radiation components to make it possible to assess the possibility of recording molecular iodine in the air. It is suggested that the spectral-phase effect will be useful for research in plasma physics and kinetic processes. References 2 Russian.  
[27-6900]

UDC 539.183.2

INVESTIGATION OF FOUR-STEP SCHEME FOR SEPARATING YTTERBIUM ISOTOPES WITH LASER RADIATION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 7, Jul 84  
(manuscript received 15 Jul 83) pp 1375-1379

BORISOV, S.K., KOTOCHIGOVA, S.A., KRYNETSKIY, B.B., MISHIN, V.A. and STEL'MAKH, O.M., Institute of General Physics, USSR Academy of Sciences

[Abstract] A four-step scheme for selective photoionization of ytterbium atoms, employing photoionization from the higher state by a CO<sub>2</sub> laser, is proposed and investigated theoretically. The first two steps are associated with  $4f^{14}6s6p - 3p0$  and  $4f^{14}6s7s - 3s_1$  states. The third excitation step transfers the Yb atoms to the Rydberg  $4f^{14}6s20p - 3p0$  state or to the state  $4f^{13}5d^26s - 1p0$ ; the fourth step transfers the atom to the spontaneous ionization state. The proposed approach can be used to



produce the rare Yb168 isotope commercially. Production of 2.6 mg/hr can be expected on the basis of the computations for an atom density of  $10^{14}$  cm<sup>-3</sup>. References 11: 5 Russian, 6 Western.  
[27-6900]

## NUCLEAR PHYSICS

## BREAKTHROUGH IN CONTAINER CONFINEMENT OF ULTRACOLD NEUTRONS

Moscow: MOSKOVSKIY KOMSOMOLETS, 3 October 84, p. 4

Okolotin, V., Candidate of Technical Sciences

[Excerpt] High-energy physics is advancing rapidly. Its tools are gigantic accelerators. Much less is known about low-energy physics, but just now Soviet scientists have made a great stride in the retention of so-called ultracold neutrons with the aid of surprisingly simple equipment.

As early as 1960, the Soviet physicist V. Vladimirovsky proposed trapping neutrons in magnetic containers, since neutrons are like miniature magnets. Containers with magnetic walls are well-known now, with the distinction that thermonuclear tokamaks confine plasma, while neutron tokamaks confine cold neutrons.

Very recently, the Soviet physicists Yu. Knevinets, V. Morozov, G. Terekhov and others achieved a great success. Ultracold neutrons in containers disappeared rapidly, perhaps due to hydrogen atoms embedded in the walls or distributed in the boundary layer. But by heating the container, scrubbing it with oxygen, and purifying the walls with an electric gas discharge, it proved possible to get rid of the hydrogen and thereby to extend the lifetime of the neutrons. Deep cooling of the walls of a small aluminum tank with liquid nitrogen and intensified formation of a thin layer of heavy-water ice made it finally possible to create a truly pure container in which the ultracold neutrons last for their whole lifetime.

But why all this effort? Ultracold neutrons are needed in optics. For a long time, not only optical but also x-ray and electron microscopes with incredibly high resolution have been successfully used. Neutron optics will aid the effort of obtaining maximum-contrast images of biological objects and of thereby determining the location and nature of individual atoms and groups of atoms. Ultracold neutrons are convenient for a more precise determination of the decay time of neutrons. It would be even more important if the electric dipole moment of the neutron could be measured. The neutron is electrically neutral, since the charges of its component proton and electron are mutually balanced. But do they cancel each other exactly at every point of the neutron? This assumption could be proved if

in elementary particles, and in ultracold neutrons in particular, the electric charges proved not to be quite evenly distributed in space.

Now that a basic method of extending the life of neutrons by means of liquid-nitrogen cooling has come at its disposal, low-energy physics will be able to elucidate this and many other unsolved problems.

FTD/ SNAP  
CSO: 1862/127

## SOLAR WIND AND COSMIC RAIN

Moscow IZVESTIYA in Russian 3 Sep 84 p 3

[Article by B. Konovalov, special correspondent, Yakutsk]

[Text] It is still difficult to become accustomed to the scales of modern scientific tools. One such instrument, occupying an area of 18 km<sup>2</sup>, has been built not far from Yakutsk. A vast area near the Yakut village of Ohtentey is covered with communication and power transmission lines that join together unique "entry towers" that register particles arriving from the depths of the Universe.

If one looks at this area--a mysterious one for the uninitiated--from the height at which eagles fly, it is quite obvious that these "towers" and the communication lines as a whole form a huge, elongated hexagon, inside which "honeycombs" of different sizes are delineated by the cables. In the center, where the "watch towers" are larger, the honeycombs are smaller, whereas on the periphery they are larger. Somewhere in the middle there is a handful of buildings: laboratories, living quarters, technical facilities.

This entire installation, which belongs to the Institute of Space Physics Research and Aeronomy, Yakut Branch, Siberian Department, USSR Academy of Sciences, is called "SHAL," which is an acronym for "extensive atmospheric showers." These showers are born when our planet encounters cosmic particles with very high energy levels that are hundreds of thousands and millions of times greater than those to which it has been possible to speed up charged particles in the most powerful terrestrial accelerators.

When such a particle, born somewhere in the tempestuous Universe, bursts into the Earth's atmosphere, a process similar to a mountain avalanche begins. Its colossal energy "smashes" the atoms that it encounters along its path. In turn, the "fragments" of this "splitting" themselves shatter other nuclei and the avalanche-type process begins. From some single point, growing gradually, rushes an extensive shower of particles with extremely variegated compositions and energy levels. And it is here, by studying those that reach the Earth's surface, that scientists reconstruct the portrait of their "ancestor."

The "SHAL" installation's 15 main watch towers catch "drops" of the cosmic rain. From the outside they appear to be small houses, inside which there are

counters that register electrons. Light engendered in the atmosphere by the movement of energized particles strikes the tops of the Cherenkov radiation counters. Four mounds that resemble hillocks conceal underground installations that are reached by only the heaviest of the "drops"--muons. In addition, radio-frequency radiation and the flow of neutrons are registered.

The information from each watch tower is sent to a central panel. If three of them that form an equilateral triangle are triggered simultaneously, that means that these are not random strangers, but part of a shower. Data on showers are automatically extracted and entered in a computer's memory.

The greater the area of an installation, the higher the probability of catching a large shower. And in order to catch infrequent newcomers with a huge amount of energy, long observation times are needed. In Yakutsk they have already been going on for more than 10 years. Because of them, terrestrial science has learned many new things about cosmic rays with gigantic energy levels. The leaders of the "ShAL" laboratory, D.D. Krasil'nikov and N.N. Yefimov, have been awarded Lenin Prizes. Right now they are preparing for a new attack on the secrets of the Universe: the "ShAL" installation is being improved.

This research is important for high-energy physics because we cannot obtain such particles in accelerators under terrestrial conditions. It is no less important for astrophysics, since cosmic rays are an inherent part of the Universe's "population." By studying them, we can gain a better understanding of the stellar world and learn how such processes take place during such gigantic cataclysms in the Universe as the flaring of supernova stars and the explosion of galactic cores.

The institute in Yakutsk is an acknowledged world leader in this scientific field. The "ShAL" installation is the largest of four scientific instruments of its type that have been built on our planet.

However, this unique installation is only one of the tools in the research complex that has been created by the Institute of Space Physics Research and Aeronomy in the vast territory of Yakutia. It can be seen as a whole, unfortunately, only from space. The institute's geophysical observatories, stations and different ranges are spread out in a meridional band from 61° to 76° North latitude; in a straight line this is about 1,500 km. Many instruments are operating in satellites. This entire complex is used to study the state of the ionosphere, magnetic fields and telluric currents, cosmic rays and radio-frequency radiation, the polar auroras and meteorological phenomena. Essentially it is a huge factory that is accumulating data so that we can understand how conditions on the Sun and in space, where our planet floats, are reflected in the state of the Earth and its surroundings.

Everyone praises his own surroundings in his own way. The institute's director, Professor Yuriy Georgiyevich Shafer, has no objection to talking about the beauties of the Lena River or showing slides with beautiful sunrises and sunsets, but all this does not begin to compare with the enthusiasm that grips him when he begins to explain the merits of the geophysical situation in Yakutia. In the vast reaches of its territory there is practically no



Industrial disturbance, the air is remarkably clear, and even the dimmest lights in the sky can be investigated during the polar night. The East Siberian magnetic anomaly is located here. It increases the strength of the Earth's magnetic field at altitudes of up to several thousand kilometers, and all the effects related to the intrusion of particles into these regions are more or less lifted upward so that it is easier to observe them from Earth (the polar auroras, in particular). Finally, the meridian passing through Yakutsk intersects the geographic and magnetic poles. In this region, by comparing data from observations made during the polar day and night it is possible to distinguish the effects on the Earth of the flow of solar particles from the effect of short-wave radiation from a star.

Yuriy Georgiyevich can talk for hours about the geophysical virtues of these regions. And I came to understand that if there is a paradise on Earth for geophysicists, it is here, in Yakutia.

Shafer himself entered this geophysical paradise in 1935, when he became the head of the Department of Physics at the Yakutsk Pedagogical Institute, which had just been founded. He is one of the original representatives of Siberian science, who from nothing--brick by brick, instrument by instrument, scientific by association--created first-class laboratories and institutes here.

The war interrupted the work on studying cosmic rays that had been begun. After the demobilization of the Guards, however, Major Yu.G. Shafer, who had passed through Stalingrad and the Kurck Bulge to dismantle Berlin since 1941, returned to his beloved work.

A precision, automatic cosmic ray counter was developed under his leadership in 1949. This AEF-1 camera became the basic tool for the creation in this country of a network of stations that registered cosmic rays on a continuous basis. Shafer was awarded the State Prize. The Yakutsk Geophysical Laboratory took shape gradually. In 1962, it was the basis for the creation of the Institute of Space Physics Research and Astronomy, which has had Yu.G. Shafer as its leader since then.

By 1 September of this year, on his 75th birthday, those at the institute calculated that he had published 178 scientific works. However, the main thing, of course, is the institute and its pupils, many of whom are Yakuts. Among the scientific workers right now there are more than 115 graduates of the Yakutsk Pedagogical Institute and the Yakutsk State University, of which more than 50 are doctors and candidates of science. They all--as in their teaching--firmly convinced that Yakutia is a geophysical paradise. And although 60-degree frosts reign in this "paradise" in winter, along with the suffocating darkness of the polar night and winds that burn the face, there are still excellent opportunities for scientific research.

Right now the institute is planning to build a new and unique instrument that is provisionally called the "Yakutsk Meridian." There already exist ionospheric stations near Yakutsk and in Zhigansk and a geophysical observatory in Tiksi that cover a huge area with their observations. To the north, on Kotel'nyy Island, expeditionary installations are in operation and it has been proposed that a permanent station be set up there eventually. If the

Ionosphere is probed synchronously from all these stations and the data are sent to a common board, then from the Earth itself it will be obvious how the solar wind blows around our planet and how changes arise in the atmosphere in connection with it.

Thanks to satellites it has now become known that the solar wind that flows from our star more or less compresses the outer lines of the Earth's magnetic field on the diurnal side of the planet. A unique tail forms on the nocturnal side. The inner lines of the Earth's magnetic field that are closest to the surface remain closed, whereas the rest are stretched out and, finally, the outermost ones break, scattering in space behind our planet like a loose braid. Since the particles move as if "climbing" these magnetic field lines, the entire pattern of the solar wind's flowing past the Earth depends heavily on their configuration.

The chain of stations will make it possible to mount a radiation patrol, from Earth, of the environs of our planet. Particles moving along the magnetic field force lines that are "stuck" to the planet are registered in Yakutsk, whereas in Zhigansk the elongated lines are studied and in Tibet the Jordan lines are investigated. On Kotel'nyy Island there will be an opportunity to observe even the direct intrusion of particles from the solar wind. As the physicists say, with the help of satellites it will be possible to calibrate this observation instrument by comparing its readings with measurements made in orbit. After that, it will be possible to dispense with the satellites.

This gigantic "instrument," which will stretch for 7,000 km, will make it possible, from the vicinity of the Earth itself, to follow what is happening in space, to evaluate the radiation situation around the planet, and to make confident forecasts for short-wave radio communications. However, the main thing, perhaps, is that this intelligent instrument will help scientists to delve deeper and better into the mechanism of solar-industrial relationships, which are one of the most difficult and important problems facing mankind today.

The geographical parallel of Yakutia will cover all mankind.

11708

CSO: 0344/0217

OPTICS & SPECTROSCOPY

UDC 543.42+621.373:535

USING LASER CORRELATION SPECTROSCOPY METHOD TO DETERMINE CONTENT OF  
GASEOUS MIXTURES

Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 57, No 2, Aug 84 (manu-  
script received 7 Mar 84) pp 179-181

KRAYLER, O. D., CHUDOVSKIY, V. L. and TRITKIN, A. I.

[Abstract] The use of a Fabry-Perot scanning interferometer in conjunction with a tunable dye laser to investigate the content of microscopic impurities in a gaseous medium is examined. The absorption spectrum of nitrogen dioxide was recorded for different concentrations and entered in a YeS 1022 computer. A program is described which is used to calculate the ratio of the integral transmission in the filter circuits when the peaks of the Airy function coincide with maxima and minima of the  $\text{NO}_2$  absorption for different concentrations of nitrogen dioxide. An experimental setup based on a nitrogen laser operating in the 430-475 nm band is described. The results indicate that laser correlation spectroscopy can be used to detect gases with a clearly defined vibrational structure of the absorption spectrum. References 7: 3 Russian, 4 Western.

[44-6900]

UDC 577.3

USE OF FLASHLAMP-PUMPED FREQUENCY-TUNABLE DYE LASERS FOR GENETIC SELECTION  
RESEARCH

Winn JOURNAL PRIKLADNOY SPECTROSKOPII in Russian Vol 44, No 3, Sep 84  
(manuscript received 17 Jun 83) pp 292-296

BOZHOLNIKOV, V. A., NIKHAYEV, S. V., KIKHELOV, I. V., LOBADOV, A. F.,  
CHALINOV, A. I., VOROBIEV, V. C., AVANESYAN, B. I., LINDENKAYA, E. I., KIKHELOVA,  
O. A. and DANILOV, A. S.

[Abstract] Experiments are described in which a Ramanov flashlamp-pumped dye laser operating at 440 - 700 nm was employed to irradiate wheat and

barley seeds in order to determine mutagenic effects. Analysis of the properties of first-, second- and third-generation plants indicates that pulsed laser radiation is an effective mutagenic factor, comparable with ionizing radiation in terms of the frequency with which modified plant forms are induced. It is found that laser radiation is significantly better than ionizing radiation in terms of producing biologically and economically valuable mutant forms. Some assumptions regarding the mechanism of the genetic effect of laser radiation on grain seeds are outlined. References: 8 Russian. [76-6900]

#### INFLUENCE OF ILLUMINATION OF CALVANOMAGNETIC CHARACTERISTICS OF TWO-DIMENSIONAL ELECTRON GAS IN STRONG MAGNETIC FIELDS

Moscow FIS'NA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 40, No 6, 25 Sep 84 (manuscript received 18 Jul 84) pp 231-233

AKZIN, V.B., VESELAGO, V.G., ZAVARITSKIY, V.N. and PROKHOROV, A.M., Institute of General Physics, USSR Academy of Sciences

[Abstract] The influence of external irradiation, primarily optical, on the quantum Hall effect in two-dimensional electron systems is investigated. n-channel metal-insulator semiconductor structures with a Hall junction geometry on the (100) surface of p-type silicon were irradiated by 1.9 eV photons, to determine the effect of changes in volumetric properties on the two-dimensional electron system formed at the boundary between two semis. The application of light to solid structures causes the two-dimensional carrier concentration to increase by as much as  $9 \cdot 10^{10} \text{ cm}^{-2}$ . This phenomenon is associated with a reduction in the volume charge concentration localized near the surface region of the structure. Long-term relaxation of carriers excited by light (up to  $10^4 \text{ sec}$ ) can be reduced down to 10 sec by exposing the system to infrared light, which transfers enough energy to the electrons to allow them to overcome the potential barrier. References 9: 3 Russian, 6 Western.

[78-6900]

UDC 535.36

#### COHERENT COMPONENT OF LIGHT FIELD SCATTERED BY SINGLE LAYER OF PARTICLES

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 28, No 10 (manuscript received 9 Dec 81) pp 876-878

DIE, V.P., LOTED, V.A. and IVANOV, A.P., Corresponding Member, Belorussian SSR Academy of Sciences, Institute of Physics, Belorussian SSR Academy of Sciences

[Abstract] The coherent component of a light field scattered by a flat single layer of particles is examined for the case of an incident plane

monochromatic wave dimension-limited by a diaphragm. Formulas are derived for the reflectance and transmittance for the case of single scattering. The theoretical data are compared with measurement results, showing good agreement for latex in water and starch in an alcohol mixture. References: 4 Russian.  
[81-6900]



EPR LASER SPECTROMETER DEVELOPED AT CHEMICAL PHYSICS INSTITUTE

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 19 Jul 84 p 4

[Article by M. Kochunov]

[Excerpt] Instruments based on the electron paramagnetic resonance effect permit the detection of impurities in infinitesimal amounts. Substances to be analyzed are placed in the resonator-chambers of these instruments and irradiated with radio waves of the length to which atoms of impurities are 'tuned'. The amount of impurities is determined on the basis of how the power of this radiation decreases as a result of absorption. The only trouble is that this method permits impurities to be detected just in the form of individual atoms, or of two- or three-atom molecules at best. For larger formations, the method's sensitivity is not sufficient. But the majority of impurities that are of interest to scientists and specialists are multiatomic molecules. How can they be identified too?

Under the direction of Professor Ya. Lebedev, associates of the chemical radiospectroscopy laboratory of the USSR Academy of Sciences' Institute of Chemical Physics undertook the solution of this problem. They decided to employ a laser which operates in the infrared and submillimetric wave bands. The laser spectrometer made it possible to determine precisely the amounts of multiatomic molecules and also of radicals -- chemically active 'fragments.'

"The idea then occurred of combining the advantages of both the laser and electron paramagnetic methods," said Professor Ya. Lebedev. "This idea has been embodied in a unit which makes it possible to do more than just determine number of impurity atoms and molecules. It makes it possible to heat, with the laser beam, the entire mixture or any of its components, or even just the surface of a substance. It is possible to break down or to 'patch' molecules, and even to produce effects directly on the chemistry of a process."

The new instrument's sensitivity is fantastic: it can 'capture' a single impurity molecule hidden in a billion (1) molecules of a basic substance.

FTD/SNAF  
CSO: 1862/75

#### LASER AEROSOL SPECTROMETER

Moscow MOSKOVSKAYA PRAVDA in Russian 10 Jul 84 p 2

[Text] A laser aerosol spectrometer intended for measuring concentrations of aerosol particles and their size has been developed at the Scientific Research Institute of Physical Chemistry imeni Karpov (NIFKHI). Passing through the laser beam, an aerosol particle scatters the light. The action of the new instrument is based on measurement of the intensity of the scattered light. Its distinguishing feature in comparison with other instruments of its type is heightened sensitivity: in one sweep it can measure as many as 20,000 particles in one liter of volume.

The laser aerosol spectrometer developed at NIFKHI can be used for measuring the dust content of air and of industrial gases in various branches of the economy. It can also be useful in environmental protection, for studying air pollution.

FTD/SNAP  
CSO: 1862/75

#### LASER FLUORIMETER FOR WATER POLLUTION MONITORING

Al'ma Ata KAZAKHSTANSKAYA PRAVDA in Russian 22 Aug 84 p 3

[Text] An ultraviolet beam that was invisible to the eye fell on an oil slick which had spread over the surface of the water, and data on the degree of pollution of the sea's surface appeared instantly on the screen of an instrument. This technology involves laser probing of impurities in water with a fluorometer. This instrument was developed at the Yerevan Special Design and Technological Bureau of Aerosol Instruments and Detectors of the USSR State Committee on Hydrometeorology and Monitoring of the Natural Environment.

This multipurpose device reacts sensitively to impurities from distances as great as 200 meters; it can therefore be used on board an airplane or helicopter. The device's operating principle is as follows: the reflected laser beam breaks down into 16 colors of the visible-frequency range, which bear data on the content of petroleum products and organic substances in the water. With the aid of a microcomputer, this information is recorded on magnetic disks in the process of the fluorometer's operation.

The instrument was tested by participants in an expedition on board the scientific research ship "Lev Titov" of the Klaypeda Hydrometeorological Observatory. Dozens of measurements were made with the instrument in the course of three weeks in the Baltic Sea. Processing of the results has shown that the fluorometer performs excellently. It can be employed also in agriculture and geology.

FTD/5NAP  
CSO: 1862/75

UDC 535.317.1

**INVESTIGATION OF BICHROMATED-GELATIN HOLOGRAM ELEMENTS FOR CONVERTING  
SPATIAL STRUCTURE OF LASER RADIATION**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 6, Jun 84  
(manuscript received 4 Aug 82) pp 1104-1110

MAYER, B.O., STASEL'KO, D.I. and YURLOVA, L.A.

[Abstract] The diffraction efficiency, light scattering and phase creep of layers of bichromated gelatin are investigated, as well as the possibility of using bichromated gelatin to produce high efficiency holographic elements for forming the spatial structure of laser beams in the visible and IR regions of the spectrum. The layers of bichromated gelatin were produced by Lin's method using commercial FP-R photographic plates. The conditions required for implementing such holographic elements employing direct hologram recording and interference copying are identified. References 15: 13 Russian, 2 Western.  
[21-6900]

**SPECTRAL BEHAVIOR OF COEFFICIENT OF REFLECTION OF BRAGG REFLECTOR**

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 10, No 15,  
12 Aug 84 (manuscript received 24 Apr 84) pp 945-949

GUREVICH, S.A., KARPOV, S. Yu. and PORTNOY, Ye.L., Physical-Technical  
Institute imeni A. F. Joffe, USSR Academy of Sciences

[Abstract] The spectral behavior of the coefficient of reflection of a Bragg reflector is analyzed by considering the discontinuity in the mean permittivity at the interface boundary between a homogeneous and a periodic medium, as well as the initial phase of the modulation of the permittivity of the periodic medium before a wide range of discontinuities and initial phases. It is found that a bleaching region exists outside the Bragg reflection band, but that there is a potential trough within the Bragg reflection band which narrows the maximum of the spectral function and displaces it with respect to the Bragg frequency. New Bragg-reflector

injection heterolaser designs are cited in which the periodic and homogeneous (amplifying) media are made of very different materials. The present findings can be used in analyzing the threshold and spectral characteristics of these devices. References 7: 5 Russian, 2 Western.  
[18-6900]

UDC 535.361.2

DETERMINATION OF INTEGRAL CHARACTERISTICS OF SIZE DISTRIBUTION DENSITY  
FUNCTION OF SUB-MICRON FRACTION OF AEROSOLS USING OPTICAL MEASUREMENT DATA

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 28, No 9, Sep 84 (manuscript received 3 Nov 83) pp 792-795

CHAYKOVSKIY, A.P., SHCHERBAKOV, V.N. and IVANOV, A.P., Corresponding Member, Belorussian SSR Academy of Sciences, Institute of Physics, Belorussian SSR Academy of Sciences

[Abstract] A simple, direct approach is presented for finding integral functional values from the size distribution density functions of the sub-micron fraction of an aerosol. It is shown possible to determine the second distribution moment even with a limited amount of optical information. The required functionals can be computed in real time from experimental results. The method facilitates optimal experiment design. References 4 Russian.  
[16-6900]

UDC 535.417

INTERFERENCE REFLECTORS WITH GLANCING INCIDENCE OF LIGHT

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA: SERIYA 3 FIZIKA, ASTRONOMIYA in Russian Vol 25, No 4, Jul-Aug 84 (manuscript received 23 May 83) pp 61-63

KLEMENT'YEVA, A. Yu., Department of Optics and Spectroscopy, Moscow State University

[Abstract] The problem of increasing the coefficient of reflection from the surfaces of optical materials to values close to unity by using multilayered dielectric systems is examined. It is found that the use of interference mirrors during glancing incidence of light is characterized by a strong dependence upon the parameters of the outer layer, a slower growth in reflection as a function of the number of layers, and the influence of matching the thicknesses of the layers and the width of the region of reflection, which must be taken into account in order to achieve good reflecting capability in experimental setups. References: 3 Russian.  
[458-6900]



UDC 539.18

**A CONTINUOUS APPROACH TO CONSIDERING INFLUENCE OF MULTIPLE SCATTERING ON  
EMISSION OF HIGH-ENERGY PARTICLES IN CRYSTALLINE AND AMORPHOUS MEDIA**

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 4, Aug 84  
(manuscript received 6 Dec 83) pp 850-853

LASKIN, N. V., MAZMANISHVILI, A. S. and SHUL'GA, N. G., Khar'kov Physical-  
Technical Institute, Ukrainian SSR Academy of Sciences

[Abstract] It is demonstrated that a continual integration method can be used to find the average relative particle radiation intensity in matter. Using this method, the study replicates Higndal's finding for the spectral density of fast particle radiation in amorphous medium; a formula is derived which describes the influence of multiple scattering on the strength of coherent radiation of a relativistic particle in a crystal. The method makes it possible to obtain quantitative results in investigating the influence of the medium on radiation processes occurring at high energies. References: 7 Russian.

[26-6900]

UDC 532.783

**OVERFOCUSING EFFECT OF OPTICAL SYSTEM WITH METAL-DIELECTRIC-SEMICONDUCTOR -  
LIQUID CRYSTAL STRUCTURE**

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 6, Aug 84 (manu-  
script received 21 Dec 83) pp 1371-1375

DUMAREVSKIY, Yu. D., KOVTUNYUK, N. F., KIRPANETS, I. N., PARTENOV, A. V.,  
PETROVICHIEVA, G. A. and SAVIN, A. I., corresponding member, USSR Academy of  
Sciences, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Polarization overfocusing which occurs in optical circuits employ-  
ing liquid-crystal space-time light modulators, and which results in two  
images with different parameters whose positions depend upon the excitation  
conditions, is described. The experimental optical setup employed to investi-  
gate the effect is described. When an image inverted in the space-time  
modulator is read out by a plane-polarized light beam (coherent or incoherent)  
two images are formed behind the analyzer on the optical axis at different  
distances from the modulator. The distance of these images from the modu-  
lator varies as the intensity of the recorded test image is varied (for fixed  
voltage across the structure), or as the voltage increases. The light  
polarization of each image differs. A physical interpretation of these  
facts, and of the effect as a whole, is provided. Figures 4; references:  
8 Russian.

[37-6900]

UDC 535.2

**SPATIAL COHERENCE OF FIELD OF SPHERICAL WAVE REFLECTED IN TURBULENT  
ATMOSPHERE**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84  
(manuscript received 28 Jun 82) pp 128-134

AKSENOV, V. P.

[Abstract] The coherence function of a reflected wave field is examined for the case in which the diffraction divergence of the sounding beam exceeds its angular divergence caused by random inhomogeneities in the medium, i.e., the case in which the sounding wave is spherical. The turbulence along the propagation path is assumed severe, and the spherical wave is reflected by a flat mirror. It is shown that the reflected wave field is statistically inhomogeneous, with the degree of spatial coherence depending upon the "center of gravity" of the observation points. The coherence radius is observed to shrink by a factor of 1.7 when the center of gravity coincides with the axis of the optical system; the radius values can exceed by a factor of 1.5 the coherence radius of the field of a wave passing once along the path. References: 13 Russian.  
[38-6900]

UDC 535.31

**OPTIMIZATION OF LIGHT BEAM WITH GAUSSIAN INTENSITY DISTRIBUTION IN DIFFRACTION-LIMITED OPTICAL ENERGY TRANSMISSION SYSTEMS**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84  
(manuscript received 5 Oct 82) pp 117-123

FEDOROV, V. B. and MITYAKOV, V. G.

[Abstract] Diffraction-limited focusing and telescopic systems employing ideal lenses (i.e., systems of lenses for which the wave aberration is less than a quarter wavelength) are examined. Systems with square and circular diaphragms are considered. Optimum Gaussian beam radii are found which maximize the light transmission coefficient of the systems. The light transmission coefficients are compared for input diaphragms illuminated by beams with Gaussian and uniform intensity distributions. The influence of error of the optical axes of the light beam and the system on the transmission coefficient of focusing and telescopic systems is investigated, as well as that of possible deviations of the radius of the Gaussian beam from optimal. The average intensity of the light beam in the plane of the output diaphragm of the optical system is analyzed. References 5:  
4 Russian, 1 Western.  
[38-6900]

UDC 535.246.21.374

#### PULSED FOURIER OPTICS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 57, No 1, Jul 84 (manuscript received 9 Feb 84) pp 8-11

HAZUREMO, Yu. T.

[Abstract] This study examines the principles of coherent transformation of time-varying light based on the capability of optical systems to perform Fourier amplitude expansion of short temporal signals. An afocal system with angular magnification of unity designed for spatial frequency filtering is examined. A transparency which compensates for the dispersion is placed in the input and output planes. The term pulsed Fourier optics is used to describe the class of optical signals and transforms which occur due to coherent spectral filtering leading to determinate amplitude and phase changes of the signal. Pulsed Fourier optical signals are defined as wave packets with dimensions smaller than those of an interferometrically exact optical instrument. The use of amplitude-phase spectrograms is examined. It is shown that if an amplitude-phase spectrogram is reconstructed like an ordinary Fourier hologram, a coherent image is formed which is the exact analog of the temporal signal stored on the spectrogram. The reverse process is also possible. Any transformations of coherent one-dimensional images which can be handled by Fourier optics can be used for amplitude-phase spectrogram analysis, synthesis and transformation of temporal signals. References 3: 2 Russian, 1 Western.  
[38-6900]

UDC 535.399.04

#### USE OF MID-IR BAND DIODE LASERS IN SPECTRAL GAS ANALYSIS

Leningrad JOURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 54, No 8, Aug 84 (manuscript received 7 Dec 83) pp 1542-1551

ZASAVITSKIY, I. I., KOSICHKIN, Yu. V., KRYUKOV, P. V., NADEZHDIINSKIY, A. I., PROKHOROV, A. N., STEPANOV, Ye. V., TISHCHENKO, A. Yu. and SHOTOV, A. P.,  
Institute of General Physics, USSR Academy of Sciences

[Abstract] The factors which limit the sensitivity of diode laser-based gas analyzers are studied, and methods are developed to improve their sensitivity. The diode laser-based spectrometers employed for gas analysis are described, and the use of spectral gas analysis to recognize and isolate the absorption due to the detected gas is discussed. The basic sources of noise and interference which limit the sensitivity of gas analyzers is studied, and methods for suppressing them are proposed. The use of correlation methods enhances the detection capability for gases with complex spectra. The methods employed made it possible to detect base

quantities of substances in the gaseous stage with resonant absorption at the level of  $10^{-6}$ - $10^{-7}$  of the recorded power. The choice of a particular gas analysis method depends upon the object of the investigation: the composition of the mixture, the characteristics of its components, the type of molecule detected and the content of the substance to be measured. Figures 7; references 15: 8 Russian, 7 Western.  
[61-6900]

OPTOELECTRONICS

DOC 851.121:621.396.969

RADAR MEASUREMENT OF THICKNESS OF DRIFTING OCEAN ICE EMPLOYING CEPSTRAL SIGNAL PROCESSING

Leningrad ZHURNAL TEKHNIЧЕСКОГО ФИЗИКИ in Russian Vol 36, No 7, Jul 86  
(manuscript received 31 Oct 83) pp 1404-1406

BOGORODSKIY, V. V., BOYARSKIY, V. I. and OLASHOVAN, A.G., Arctic and Antarctic Scientific Research Institute, Leningrad

[Abstract] The use of cepstral processing for radar signals reflected by year-old drifting ice in contact radar probing is investigated. Radar measurements were taken over a path 10,000 km long using equipment carried aboard an Il-14 airplane. Collection flights were made at an altitude of 150 meters. More than 8,000 reflected signals were processed by computer, using cepstral probability and correlation algorithms. The standard deviation of the thickness measurement error was found not to exceed 10% for a thickness range of 0.3 - 1.7 m. Cepstral processing methods for reflected radar signals make it possible to obtain a statistically valid distribution of the ice thickness along the flight path. References 7 Russian.

[27-6900]



# PLASMA PHYSICS

CNC 117,529,001,26

## DEVELOPMENT OF THEORY OF HIGH-CURRENT HIGH-PRESSURE PULSED ARC

Source ELEKTROKHEMIYA in Russian No 9, Sep 64 pp 23-29

SHOSTAKOV, V. V., LEBANOV, A. B. and UL'YANOV, K. B., Moscow

[Abstract] Stagninsky's homogeneous model of the development of high pressure pulse impulse arc is extended to allow for change in the arc temperature and its electrical conductivity over time; the connection between pressure and the velocity of the shock wave front is discarded, and allowance is made for the intrinsic magnetic field of the arc. A system of ordinary differential equations is derived to describe the parameters of a high pressure impulse arc which allows for the real properties of the gas; it is found that the radius of the arc depends mainly upon the external parameter  $I_0/\gamma$  (ratio of initial current to its period of oscillation) with the temperature and resistance also depending strongly upon the initial radius and pressure. The intrinsic magnetic field retards the expansion of the channel and increases its temperature and resistance. Because of the high resistance of the arc, the system of equations must be solved jointly with the equation for the external circuit when the initial radii are small. Figures 3, references: 11 Russian, [101-4800]

## RADIATION COLLIMATION OF ATOMIC BEAM BY TWO-DIMENSIONAL LASER COOLING

Source FIZIKA I EKSPERIMENTAL'NAYA TEORIYA (CHISLA FIZIKI) in Russian Vol 40, No 6, 23 Sep 64 (manuscript received 11 Aug 64) pp 251-255

RAVVA, V.I., LEVCHEN, V.G. and SIKHIN, A.I., Institute of Spectroscopy, USSR Academy of Sciences

[Abstract] Radiation collimation and two-dimensional cooling of an atomic beam by intense laser radiation is described. In radiation collimation, the beam of atoms is irradiated by an asymmetrical light field whose frequency is shifted into the red region with respect to the atomic transition frequency. The asymmetrical field is formed by reflecting laser radiation from

11 April 1985

a conical mirror. Light pressure acts upon atoms in the field; this force narrows the velocity distribution of the atoms across the axis of the conical mirror, which reduces the angular divergence of the beam, i.e., collimates it. An experiment is described in which two-dimensional radiation cooling of a beam of sodium atoms in an asymmetrical standing light wave is investigated. The transverse motion temperature is reduced from 42 mK to 3.5 mK during collimation. It is concluded that the use of a long collimator or a retarded atomic beam will make it possible to increase beam density and to obtain beams with the smallest possible transverse temperature.

Reference 8: 3 Russian, 3 Western.

[78-0900]

UDC 533.951

#### NONLINEAR WAVES IN PLASMA IN STRONG MAGNETIC FIELD

Thelal SHERMCHENIYA AKADEMI: RAIN CHISTOVICH 888 in Russian Vol 134, No 2, May 84 (manuscript received 11 Feb 83) pp 297-300

BEREZIANI, V. I. and SHAFAROV, S. I., Institute of Physics, Georgian SSR Academy of Sciences, Thelal State University

[Abstract] A system of equations (derived elsewhere) for low-frequency perturbations propagating along an external uniform constant magnetic field is investigated systematically. Conditions are identified under which "oblique" Langmuir waves can generate several types of solitons: subsonic refraction solitons, supersonic compression solitons and supersonic "capped" solitons. Reference 8: 1 Russian, 3 Western.

[68-4900]

UDC 533.95

#### TWO-DIMENSIONAL MODEL OF PLASMA NEAR WALL OF TORUS WITH POLYHEDRAL DIVERTER

Science DOKLADY AKADEMI: RAIN 888 in Russian Vol 278, No 2, Apr 84 (manuscript received 18 Jan 84) pp 328-343

CHIRKINOV, Ye. I., KIRICHENKO, A. S., PIGAROV, A. Ye. and PLOTNICHENKO, V. I., Institute of Atomic Energy (Inst) I.V. Kurchatov

[Abstract] A self-consistent two-dimensional model is presented which describes the transfer processes in the plasma near the wall of a tokamak with a polyhedral divertor consisting of the divertor itself plus a divertor layer in the main chamber. The plasma is described by two-dimensional hydrodynamic equations, and Monte Carlo modeling is used for the neutral gas. A geometry is employed which makes it possible to pose natural boundary conditions; the boundary conditions on the divertor plate are based on the

requirement that the hydrodynamic impulse and energy flux exiting the plasma be transferred to the plate in the form of kinetic fluxes. Modeling of the diverter experiment is done with the ARDEX system ( $L = 15\text{ cm}$ ,  $R = 3\text{ cm}$ ). It is found analytically that the transfer of energy to the diverter space is determined mainly by electron heat conductivity. Longitudinal gradients occur because of the strong relationship between the coefficients of classical longitudinal heat conductivity and temperature. The primary mechanism underlying radiation losses of energy in the diverter is found to be excitation and ionization of atomic hydrogen. The self-consistent physical model of the processes underlying plasma transfer in the diverter layer of the ARDEX system explains the basic experimental understandings and makes it possible to understand the processes which occur. References 7; 5 Russian, 1 Western.

[82-6900]

UDC 533.9

# SPREAD-FUNCTION COMPARISON OF DIFFERENT PROBE METHODS FOR MEASURING ELECTRON ENERGY DISTRIBUTION IN PLASMA

RUSSIAN TEPLOFIZIKA VYSHKIEY TEMPERATUR in Russian Vol 22, No 4, Jul-Aug 84 (manuscript received 6 Jun 83) pp 757-761

VOLODINA, L. M., DENISOV, V. I., KOLCHENKOV, S. B. and ERAL'EVA, Ye. A., Leningrad State University Inzini A. A. Zhukov, Moscow State University Inzini M. V. Lomonosov

[Abstract] The spread functions of probe methods for measuring the electron distribution function by velocities are introduced in order to compare the three most common methods for differentiating probe characteristics: probe current modulation, differentiation by means of differentiation networks (amplifiers), and numerical differentiation. These methods are compared in terms of resolution and induced distortions; the influence of the type of spread functions on the accuracy with which the true distribution functions are recovered from the measurement results is assessed by solving model problems using the regularization method. Figures 6; references 11; 8 Russian, 1 Western.

[84-6900]

INITIAL STAGE OF DISCHARGE THROUGH METAL WIRES IN HIGH-CURRENT ACCELERATOR  
DIODE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 10, No 18,  
26 Sep 84 (manuscript received 3 Apr 84) pp 1145-1149

ZAKHAROV, S.N., IVANENKOV, G.N., KOLOMENSKIY, A.A., PIKUZ, S.A. and  
SAMOCHIN, A.I., Physics Institute imeni P. N. Lebedev, USSR Academy of  
Sciences

[Abstract] Skin current in an expanding plasma formed by the surface explosion of 'thick' wires is investigated in order to provide an explanation for the 'double obscurogram' observed in a previous study by the author. The estimates are illustrated by the example of an aluminum wire 10  $\mu$ m in diameter and 1 cm long. The cold, dense, highly-ionized plasma which forms as the metal wire explodes is analyzed. The thickness of the skin layer which forms as the plasma heats up is analyzed. A formula is derived for the energy losses with allowance for bremsstrahlung and recombination radiation. The ion distribution by ionization frequencies is analyzed. It is found that the 'double obscurogram' corresponds to luminescence of a thin surface layer during the phase of the fastest growth in the current.

References 4: 2 Russian, 2 Western.

[90-6900]

UDC 533.9

INVESTIGATION OF RELAXATION PROCESSES OF EXCITED STATE POPULATIONS IN PLASMA  
PRODUCED BY POWERFUL NANOSECOND PULSE DISCHARGE IN NEON

Leningrad VESTNIK Leningradskogo Universiteta: FIZIKA, KHIMIYA in Russian  
Vol 16, No 3, Aug 84 (manuscript received 16 Nov 83) p. 85-88

ASHURBERG, S.A., YELUSHOV, V.S. and BORISOV, V. B.

[Abstract] The processes underlying the relaxation of excited state populations in neon with a  $2p^3$  electron configuration caused by short (a few hundred nanosecond) powerful voltage pulses applied to an inert gas are investigated. The experimental discharge was ignited in a glass tube 0.5 cm in diameter and 20 cm long fitted with internal electrodes. A voltage pulse with variable amplitude of 5 - 20 kV approximately 400 ns long was applied to the discharge tube. The excited atom concentration was measured by the complete absorption method, employing a dye laser probe. The ion composition of the plasma was investigated with the help of a quadrupole mass spectrometer; electron concentration and temperature information were obtained by the dual probe method. The initial excited levels were highly populated at the beginning of the discharge, and the contribution to ionization was insignificant. As the electron concentration increased and the temperature of the electron gas dropped, the ionization channel with excited level 1 predominated, causing an avalanche increase in  $n_e$  and a drop in the concentration of excited atoms. The increase in excited atoms concentrations observed after the discharge was associated primarily with dissociative recombination of  $Ne^+_2$  molecular ions. References: 6 Russian.

[95-4900]

THRESHOLDS OF OCCURRENCE OF DIFFERENT STATES OF NON-EQUILIBRIUM IONIZED  
SURFACE PLASMA INITIATED BY ACTION OF LASER RADIATION ON METALS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 10, No 5,  
12 Aug 84 (manuscript received 12 Mar 84) pp 953-957

VOROB'EV, V.S. and KHOMKIN, A.L., Institute of High Temperatures, USSR  
Academy of Sciences

[Abstract] The different states of a non-equilibrium ionized surface plasma initiated by millisecond laser pulses on metals in atmosphere of atomic gases are demonstrated. It is found that substantial ionization of the surrounding gas can be maintained with lower laser radiation intensities than are needed to break down the vapors of the target material. An equation and criteria are derived which make it possible to find the laser radiation intensity causing vapor breakdown, primary gas breakdown and discharge extinction in the primary gas. References 3 Russian.  
[18-6900]

UDC 537.534.2

FORMATION OF ION BEAMS WITH HIGH PHASE DENSITY OF CURRENT NON-STEADY-STATE  
FROM PLASMA AS APPLIED TO DEVELOPMENT OF ION SOURCES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 8, Aug 84  
(manuscript received 17 Jul 83) pp 1628-1631

BASOVA, T. A., BYKOVSKIY, Yu. A. and NEVOLIN, V. N., Moscow Engineering-  
Physics Institute

[Abstract] The processes occurring in the formation of ion beams and the possibility of their focusing and further use are investigated in detail in order to develop laser ion sources for various practical applications. The ion focusing system in a laser source employing a single lens is designed and analyzed. The ions are accelerated by a uniform field in the space between two parallel grids. The beam is focused by a conical electrode whose shape and position are selected to minimize system aberration. The emittance patterns are taken in three cross sections of the beam in the crossover region by sequential stopping. The use of the source for direct ion doping is discussed. The optimum parameters of the laser radiation on the target are found, and the possibility of using the source for various purposes is demonstrated. Figures 4; references: 4 Russian.  
[61-6900]



UDC 551.594

INVESTIGATION OF DENSE CLUSTER PLASMA FORMED BY ELECTRON BEAM

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 8, Aug 84  
(manuscript received 28 Feb 84) pp 1538-1541

STAKHANOV, I. P., Moscow State Institute of Precision Chemical Technology  
imeni V. M. Lomonosov

[Abstract] The author analyzes eyewitness accounts of ball lightning and concludes that if such lightning actually consists of a cold nonideal plasma at near room temperature, it should be of positive and negative ions covered by clouds of neutral molecules (such as water). Such a cluster of plasma becomes nonideal at temperatures of approximately 500K when the ion density is greater than about  $10^{15} \text{ cm}^{-3}$ . If the beam is interrupted rapidly enough, the medium through which it passes will not have enough time to heat up, so that the positive and negative ions become clusters with hydride envelopes. The possibility of generating such a highly non-equilibrium plasma by means of modern high-current accelerators is assessed. References 8: 6 Russian, 2 Western.  
[61-6900]

UDC 537.533.79

THE ROLE OF RECOIL IN QUANTUM MODULATION EFFECT OF CHARGED PARTICLE BEAMS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 8, Aug 84  
(manuscript received 4 Aug 83) pp 1472-1478

OGANESYAN, S. G. and YENGIBARYAN, V. A., Scientific Research Institute of Physics of Condensed Media, Yerevan State University

[Abstract] The use of laser radiation to modulate a particle beam is investigated. It is shown that a particle must obtain second-order recoil with respect to Planck's constant during the emission-absorption of a photon in order for quantum modulation of the density of a beam of electrons to occur. A fundamental connection is found between the condition for the existence of the quantum modulation effect and the condition for the existence of amplification in a free-electron laser. Based on the balance relationships for the number of absorbed and emitted photons, the appearance of regions in which emission processes dominate absorption processes is possible only when the probabilities of these processes are different, or when different particles participate in both processes. The particle likewise must obtain second-order recoil with respect to Planck's constant. A method is proposed for removing recoil degeneracy by using a dielectric medium; the quantum modulation percentage of the particle beam density is found. A number of studies devoted to recoil in the quantum modulation effect are analyzed. References 16: 15 Russian, 1 Western.  
[61-6900]

# LASER-PLASMA DETECTION OF DIFFERENCE FREQUENCY OF TWO LIGHTWAVES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 40, No 3, 10 Aug 84 (manuscript received 29 Jun 84) pp 114-116

BASOV, N.G., VASIL'EV, B.I., GRASYUK, A.Z., LOSEV, L. L. and MESHALKIN, Ye. A., Physics Institute imeni P.N. Lebedev USSR Academy of Sciences

[Abstract] It is established that the amount of current from a charged metallic target to a surrounding optical breakdown plasma during a nano-second laser pulse is approximately proportional to the intensity of the laser radiation, i.e., that the current pulse between the target and the conducting medium has the same shape as the light pulse. This property of the current is equivalent to optical detection, i.e., to obtaining an electrical signal proportional to the envelope of the optical oscillations. This optical detection makes it possible to study current pulses near a target at the same frequency as the amplitude modulation frequency of the laser radiation. References 3 Russian.

[19-6900]

# ONE-DIMENSIONAL GAS DYNAMIC MODELING OF ELECTRON BEAM TRANSPORT IN RARIFIED GAS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 87, No 3, (9), Sep 84 (manuscript received 9 Apr 84) pp 840-848

MIKHAYLOV, A.V., GUSEVA, G.I., ZAV'YALOV, M.A., ROSHAL', A.S. and RUKHADZE, A.A., All-Union Electrotechnical Institute imeni V. I. Lenin

[Abstract] A quasi one-dimensional modification of the gas dynamic model is proposed which makes it possible to model the space-time dynamics of beam-plasma interaction with allowance for transverse restriction of the system. Beam propagation in a rarified gas is analyzed, with allowance for a self-consistent electrical field, in the two-fluid gas dynamic approximation. The conditions under which beam-plasma oscillations and instabilities result in complete deceleration of the beam are analyzed. Nonlinear interaction between the electron beam and the plasma resulting from shock ionization was numerically simulated. When the system significantly exceeds the radius of the beam in the actual experiment, the model exhibits a strong increase in plasma-beam oscillations. References 13: 9 Russian, 4 Western.

[69-6900]

EXPERIMENTAL AND THEORETICAL FINDINGS ON IRRADIATION OF SPHERICAL MICRO-TARGETS BY TERAWATT IODINE LASER

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 87, No 2, Aug 84 (manuscript received 2 Jan 84) pp 417-428

AVRORIN, Ye.N., YEROSHENKO, V.A., ZARETSKIY, A.I., ZUYEV, A.I., KORMER, S. B. (deceased), KOCHIMASOV, G.G., KRYUCHENKOV, V.B., LYKOV, V. A., MURUGOV, V.M., RYADOV, A.V., SENIK, A. V. and SUKHAREV, S.A.

[Abstract] Experiments performed on the Iakra-IV setup to compress DT-gas filled spherical microtargets by using radiation from an iodine laser with  $\lambda = 1.315 \mu\text{m}$  are interpreted by the "Zarya" ("Glow") program. Simulated optimization of targets for the Iakra-IV setup is described. It is found that a neutron yield of  $10^8$  neutrons per pulse can be expected when the focusing conditions are optimized and the laser radiation power on the target is raised to the 2 TW level. The analytical and experimental results agree well for all of the parameters except the neutron yield in a number of experiments. References 5: 4 Russian, 1 Western. [28-6900]

UDC 533.951

STUDY OF BREAKDOWN IN Ar AND He AT LOW PRESSURES BY  $\text{CO}_2$ -LASER RADIATION

Moscow FIZIKA PLAZMY in Russian Vol 10, No 4, Jul-Aug 84 (manuscript received 5 Jul 83) pp 762-768

DATSEVICH, N.P., KARLOV, N.V., KONONOV, N.N., KUZ'MIN, G.P., NESTERENKO, A.A., RUKHADZE, A.A., PROKHOROV, A.M. and TOKER, G.R., Institute of General Physics, USSR Academy of Sciences

[Abstract] The laser breakdown plasma created in Ar and He at near-threshold pressures for 10-micron radiation from  $\text{CO}_2$  laser at intensities of approximately  $10^{11} \text{ W/cm}^2$  is investigated. Breakdown at low pressures in Ar and He is found to be characterized by rapid discharge propagation velocities which cannot be explained by a hydrodynamic propagation mechanism; strong ionizing waves propagate into the gas surrounding the breakdown plasma at velocities exceeding the shockwave velocities which can now be obtained in shock tubes. When shockwaves propagate in Ar at  $P \approx 20 \text{ mm Hg}$  an ionized region forms ahead of its front which has not yet been fully investigated. When the pressure in Ar and He is increased to 100 mm Hg and higher, the propagation mode of the laser discharge changes. References 10: 7 Russian, 3 Western. [14-6900]

UDC 533.9.01

CONVERSION OF KINETIC ENERGY OF SUPERSONIC PLASMA FLOWS TO SHORT-WAVE RADIATION DURING IMPACT AGAINST WALL.

Moscow FIZIKA PLAZMY in Russian Vol 10, No 4 Jul-Aug 84 (manuscript received 2 Jun 83 after revision) pp 722-729

GRYUKANOV, M.F. and KONKASHBAYEV, I.K., Institute of Atomic Energy imeni I.V. Kurchatov.

[Abstract] The dynamics of cooling of a plasma behind a shock wave front are examined in order to identify the parameters for which the kinetic energy of the plasma is efficiently converted to radiant energy. It is shown that a shock wave with an associated radiant cooling wave which moves upstream along the flow at a constant rate occurs when these flows interact with a wall or a counter flow. The dynamics of entering the steady-state condition are examined; problems with different concentrations of carbon impurities are solved numerically as an example. References 9 Russian. [14-6900]

UDC 533.951

RUNAWAY ELECTRONS AND PLASMA TURBULENCE IN STELLARATOR WITH OHMIC CURRENT

Moscow FIZIKA PLAZMY in Russian Vol 10, No 4, Jul-Aug 84 (manuscript received 3 May 83 after revision) pp 703-714

VOLKOV, Ye.D., PEREPELKIN, N.F., SUPRUNENKO, V.A. (deceased), ARSEN'EV, A.V., BURCHENKO, P.Ya., VASIL'EV, M.P., KOTSUBANOV, V.D., KILAGA, A.Ye., RUTSOV, K.S. and SLAVNYI, A.S., Khar'kov Physical-Technical Institute, Ukrainian SSR Academy of Sciences.

[Abstract] The restriction and cutoff of free electron acceleration in a magnetized ohmic discharge plasma occurring with electrical fields of  $E > 0.1 E_{cr}$  in Uragan-2 and Sirius stellarators are investigated. Three plasma heating modes are established as a function of the ratio  $E/E_{cr}$  which are associated with the occurrence of a 'tail' on the electron distribution function: free (runaway) acceleration for  $E < 0.1 E_{cr}$ , restricted acceleration for  $E \approx (0.1 - 1) E_{cr}$  and total cutoff of free acceleration ( $E > E_{cr}$ ). Cutoff of free electron acceleration is found to occur throughout the entire plasma filament, and is not associated with the MHD-activity of the plasma or lost accelerated particles from the trap. The acceleration cutoff phenomenon is dissipative, since it results in complete heating of the electrons and ions. References 39: 26 Russian, 13 Western. [14-6900]



# USE OF IMPULSE PROBE FOR STATIONARY DENSE PLASMA DIAGNOSTICS IN PRESENCE OF CHEMICAL REACTIONS

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 4, Jul-Aug 84  
(manuscript received 16 Apr 83) pp 70-77

ARAVIN, G.S., VLASOV, P.A., KARASEVICH, Yu.K., MAKOLKIN, Ye.V. and  
POLYANSKIY, V.A., Moscow

[Abstract] A stationary dense plasma in which chemical ionization and recombination reactions are occurring is examined with a discontinuous potential, with respect to the plasma, applied to the probe. The dynamic properties of the probe-plasma system are investigated. It is found analytically and experimentally that the concentrations of charged particles found from the transient currents when the probe potential is pulsed agree satisfactorily with the concentrations determined from probe measurements with a constant probe potential for stationary charged particle concentration in the plasma. The charged-particle recombination coefficient found by using both methods in combination is close to the values cited in the literature. When the charged-particle recombination coefficient is known, a pulse probe can be used to find the mobility factor of the positive ions. Charged-particle concentrations found by probe measurements are 1.5 - 2 times higher than the electron concentrations measured interferometrically. References 11: 10 Russian, 1 Western.  
[29-6900]

UDC: 533.92:621.034.62

# POSSIBLE MECHANISM UNDERLYING CONTAMINATION OF PLASMA IN THERMONUCLEAR INSTALLATIONS BY VOLATILE IMPURITIES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 7, Jul 84  
(manuscript received 23 Jun 83 after revision) pp 1412-1414

VOYTSENYA, V.S. and VASIL'EV, V.V., Khar'kov Physical-Technical Institute, Ukrainian SSR Academy of Sciences,

[Abstract] A new mechanism underlying the contamination of plasma by volatile impurities is discussed. It is suggested that when the contaminated metal surface of the limiters and walls of the vacuum chambers are sputtered, negative ions - primarily oxygen ions - are released. When the plasma contacts these surfaces, secondary ions with different charges are released, resulting in contamination. This mechanism explains the ineffectiveness of the diverter employed in the DITE tokamak with respect to uncontrolled oxygen release, as well as the strong effect in the plasma sheath from slow oxygen atoms formed during dissociation of  $O_2$  molecules injected into the vacuum chamber. References 20: 2 Russian, 18 Western.  
[27-6900]



UDC 533.932

# HIGH-EFFICIENCY CONVERSION OF LASER RADIATION IN PLASMA TO SOFT X-RAYS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 7, Jul 84  
(manuscript received 14 Jul 83) pp 1386-1387

KAS'YANOV, Yu.S., LEONOV, Yu.S. and PLESHKOV, G.M., Physics Institute  
Imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] The achievement of significant values of laser-to-x-ray conversion efficiency in plasma  $\eta_{\max}$  and  $\eta_{\max}/\eta_{\min}$  during irradiation of massive targets made of bismuth and gold with sharp focusing of laser radiation at  $\lambda = 0.53 \mu\text{m}$  is reported. The soft X-rays from the laser plasma were measured by a pyroelectric receiver placed in the vacuum chamber 10 - 30 cm from the target. The conversion coefficient is measured as a function of the cosine of the angle between the normal to the surface and the direction of observation for three targets. The quantity  $\eta_{\max} = 0.21 \pm 0.05 \text{ sr}^{-1}$  and  $\eta_{\max}/\eta_{\min} = 7 \pm 1$  for a bismuth target; the values of  $\eta$  are approximately an order of magnitude smaller for aluminum, and 2 to 3 times larger than the values found by Mead, Campbell, et al. It is found that practically all the laser energy is absorbed in the plasma corona, and in that part of the plasma where the electron density is subcritical. Because of electron heat conductance and the flow of X-rays, the dense plasma is heated within the target. The region in which this occurs is the main source of soft X-rays, which has substantial directional anisotropy. References 7: 4 Russian, 3 Western.  
[27-6900]

UDC 537.533

# PLASMA SCREENING EFFECT ABOUT QUASI-NEUTRAL BUNCH OF NEGATIVE IONS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 54, No 7, Jul 84  
(manuscript received 9 Jun 83) pp 1362-1364

GORETSKIY, V.P., NAYDA, A.P. and SIMONENKO, L.S., Institute of Physics,  
Ukrainian SSR Academy of Sciences.

[Abstract] A high-frequency probe method was used to measure the electron concentration in a plasma beam. The experiments were conducted with a pulsed beam of  $\text{H}^-$  ions with energy of up to 13 keV and current of up to 100 mA. An HF probe made up of the ends of the center conductors of cables 3 mm long were arranged in a line perpendicular to the axis of the beam opposite one another and spaced 4 mm apart. HF voltage from a generator was applied to the transmitting probe, and the signal from the receiving probe was amplified, detected and output to an oscillograph. The electron concentration for pressure  $P \approx P_0$  in the center of the beam is found to be smaller than the concentration in the outer part of the beam. The exterior plasma serves as a shield for the low-frequency perturbation fields in the beam. References 10: 8 Russian, 2 Western.  
[27-6900]

## STRESS, STRAIN AND DEFORMATION

### SHOCK-WAVE DEFORMATION OF TITANIUM CARBIDE CERAMIC

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 4, Jul-Aug 84  
(manuscript received 18 Apr 83) pp 85-87

KANEL', G.I. and PITYULIN, A.N., Chernogolovka.

[Abstract] Wave profiles in a titanium carbide (80% by weight) ceramic material with nickel binder are registered and analyzed. The specimens were prepared by self-propagating high temperature synthesis. Titanium-carbide based ceramic subjected to shock-wave loading is found to deform like an elastic body with  $\eta \sim 10^4$  kg/m-s and breaking strength of approximately 0.5 GPa. References 9: 5 Russian, 4 Western.  
[29-6900]

### NUMERICAL MODELING OF HIGH SPEED IMPACT FOR DIFFERENT DENSITY RATIOS OF IMPACTOR AND TARGET

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 4, Jul-Aug 84  
(manuscript received 5 Apr 83) pp 117-121

MALAMA, Yu.G., Moscow.

[Abstract] The impact of two materials on aluminum is examined: tungsten with velocities of 7.16 and 40 km/s, and gas with initial density of  $0.1 \text{ g/cm}^3$  at  $V = 16 \text{ km/s}$ ; and of iron on gabbroid anorthosite at  $V = 15 \text{ km/s}$ . The strength properties of the target are considered by a rigid-plastic approximation. The shape of the crater formed for moderate impact velocities of less than approximately 7 km/sec is near-hemispherical for targets of density ratio  $\mu \sim 1$ . The relative crater depth increases for moderate velocities as  $\mu$  increases; craters become cup-shaped for impact velocities which are higher, the greater  $\mu$ . Finally, when  $\mu \ll 1$  in spite of the short effective impact interaction length, flattened craters are formed, which tends to refute the similitude criteria proposed by Deans and Wolf. References 10: 5 Russian, 5 Western.  
[29-6900]

THERMODYNAMICS

UDC 536.241:535.211

HEATING OF THIN FILMS BY LASER RADIATION CONSIDERING TEMPERATURE BEHAVIOR  
OF COEFFICIENT OF REFLECTION

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 47, No 4, Oct 84  
(manuscript received 4 Jul 83) pp 642-647

KAPEL'YAN, S.N. and MORGUN, Yu. F., Belorussian Polytechnical Institute,  
Institute of Electronics, Belorussian SSR Academy of Sciences

[Abstract] The thermophysical problem of heating of thin metal films on semiconductor substrates by a square laser pulse is investigated. Expressions are derived for the temperature of the metal film and substrate. The heating of a silver film on a silicon substrate is studied as an example. The dimensionless temperature of the film is computed as a function of dimensionless time for a linear relationship between absorbing capacity and temperature and for a fixed absorbing capacity. The findings show that the relationships derived can be used to compute film and substrate temperature when the relationship between the film reflecting capacity and temperature is linear. References 12: 10 Russian, 2 Western.  
[99-6900]

LOW-TEMPERATURE THERMAL EXPANSION OF GLASS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 40, No 7, 10 Oct 84 (manuscript received 24 Jul 84) pp 283-286

GAL'PERIN, Yu. M., GUREVICH, V. L. and PARSHIN, D. A., Physical-Technical Institute imeni A. F. Joffe, USSR Academy of Sciences

[Abstract] A study of thermal expansion of glass is proposed to account for experimental findings according to which the coefficient of thermal expansion of glass at low temperatures is proportional to temperature, so that Gruneisen's ratio  $\alpha_T = \text{capital gamma} C/K$  holds, where  $C$  is the specific heat capacity and  $K^{-1}$  is the bulk modulus. It is found that the coefficient of thermal expansion of glass at low temperatures is a linear function of temperature and is caused by the occurrence of "two-level systems" (similar

to MIVP model of low temperature glasses). Gruneisen's constant  $\Gamma$  is found to be anomalously large (of the order of  $10^2$ ), because of the softness of the local atomic potentials on which the two-level systems are realized. The main contribution to the coefficient of thermal expansion is unsteady, i.e., it depends upon the duration of the experiment. The contribution of two-level systems to  $\alpha_p$  in the case of metallic glass is combined with the contribution from conduction electrons, which is positive in the free-electron model. That contribution is also proportional to time and is of the same order of magnitude as contribution of the two-level system. References 7: 4 Russian, 3 Western.  
[98-6900]

ASSESSMENT OF INFLUENCE OF SUBSURFACE LAYERS ON MEASURED NOISE TEMPERATURE OF BALLISTITE POWDER

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 4, Jul-Aug 84 (manuscript received 11 Mar 83) pp 37-39

ZENCHENKO, V.M. and IVASHCHENKO, Yu.S., Krasnoyarsk.

[Abstract] The influence of subsurface layers of ballistite powder on the measured surface temperature is investigated analytically. An expression is derived for the deviation of the measured noise temperature from the true surface combustion temperature of the powder. The electrical conductivity activation energy of the powder is found experimentally. The measured surface noise temperature is found to be practically the same as the true temperature because of the small influence of the subsurface powder layers which, in turn, is due to the difference in their electrophysical properties. References 3 Russian.  
[29-6900]

MATHEMATICS

UDC 519.8

SUFFICIENT MINIMUM CONDITIONS FOR NONLINEAR PROGRAMMING PROBLEMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 278, No 1, Sep 84 (manuscript received 1 Nov 83) pp 24-27

VEYTSHEV, Yu.G. and PUTOV, V.A., Computer Center, USSR Academy of Sciences

[Abstract] A general nonlinear programming problem  $\min f(x)$  is examined where  $x \in X \subset \mathbb{R}^n$ ;  $\mathbb{R}^n$  - an  $n$ -dimensional Euclidean space. The function  $f(x)$  is defined on  $X$ , and takes on values in the real domain. An approach is described which allows the initial problem to be solved by different numerical methods for solving systems of nonlinear equations in conjunction with methods for finding the minimum on sets of simple structure. References 2 Russian.  
[74-6900]

UDC: 591.524.1:591.177:532.526

THE NATURE OF UNDULATORY OSCILLATIONS OF FISH BODIES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 278, No 3, Sep 84 (manuscript received 25 Jan 83) pp 571-574

SOROKODIN, Ye. D., Taganrog Electrical Engineering Institute Imeni V. D. Kalmykov.

[Abstract] The physical nature of the formation of undulatory oscillations of the bodies of fish is investigated. Specimens of *Lucioperca lucioperca* L., *Abramis brama* L. and *Perca fluviatilis* L. were secured in swimming position in calm water by a clamp, which was made to oscillate (through  $\pm 15^\circ$ ) in the horizontal plane about the vertical axis, i.e. lateral oscillations were transmitted to the fish body. Waves traveling in the caudal direction similar to those occurring in a live fish were observed for frequencies of 0.5-3 cycles per second. As the frequency of the oscillations was increased, the wave traveling in the caudal direction was partially reflected from the



tail, resulting in superimposed traveling and standing waves on the body of the fish. The phase velocities of the wave and the swimming velocity are computed as a function of the oscillation frequency. References 14: 10 Russian, 4 Western.  
[96-6900]

UDC 519.21

# PROPERTIES OF RANDOM SUB-GAUSSIAN TYPE PROCESSES

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR; SERIYA A FIZIKO-MATEMATICHESKIY I TEKHNIЧЕСKIIY NAUKI in Russian No 9, Sep 84 (manuscript received 17 Feb 83) pp 14-16

KOZACHENKO, Yu.V., Kiev State University Imeni T.G. Shevchenko

[Abstract] Random processes defined on a compact metric space such as  $M^2(t) = 0$  and  $Mexp[\lambda t(t)] = \exp[\theta(\lambda)]$  for  $\lambda = t(\lambda) =$ , where  $\theta(\lambda)$  is an Orlich  $\Phi$ -function, are considered. It is shown that these processes belong to the Orlich space generated by the function  $\Phi(x) = \exp[\theta(x)] - 1$ , where  $\theta^*(x)$  is the complementary function of  $\theta(x)$ . Conditions are derived under which the processes  $\xi(t)$  have a probability of unity of being selectively continuous; conditions are also derived under which a series of independent identically distributed random processes  $\gamma_n(t)$  satisfies the central limit theorem if the random process  $\{a, p, 16\}$  converges weakly to a Gaussian process in  $C(Y)$ . References 7: 4 Russian, 3 Western.  
[80-6900]

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UDC 519.217.8

# A NECESSARY CONDITION FOR OPTIMALITY OF STOCHASTIC CONTROL SYSTEMS

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 114, No 1, Apr 84 (manuscript received 17 Dec 82) pp 29-32

TEVZADZE, R.N., Institute of Cybernetics, Georgian USSR Academy of Sciences.

[Abstract] A necessary condition for optimum control of a stochastic system is derived on the basis of Hausman's theorem for a certain class of problems. References 2: 1 Russian, 1 Western.  
[83-6900]

UDC 62-50

CONTROL OF NONSTATIONARY OBJECT WITH CONTROLLED OBSERVATION PROCESS

Baku IZVESTIYA AKADEMII NAUK AZERBAIDZHANSKOY SSR: SERIYA FIZIKO-  
TEKHNIЧЕСКИХ I MATEMATICHESKIKH NAUK in Russian Vol 5, No 1, Jan-Feb 84  
(manuscript received 1 Jun 83) pp 103-108

ABRAMOV, A.Kh. and DAGESAMANSKIY, N.D., Institute of Cybernetics, Azerbaijan  
SSR Academy of Sciences.

[Abstract] A nonstationary object of control described by an equation  
linearized with respect to the nominal trajectory is investigated. The  
optimality criterion is the additive losses associated with the penalty for  
the actual coordinate of the process deviating from the required value and  
with the cost of observing said output coordinate. The minimization problem  
consists of constructing pairs of controls in observations which minimize the  
total risk. A quasi-optimal control strategy is constructed which makes it  
possible to arrange the observations a priori on the basis of the parameters  
of the criterion and the dispersion of the noise in the object. References:  
3 Russian.  
[20-6900]

UDC 519.714

AN OPTIMALITY CRITERION FOR A DECODING ALGORITHM FOR MONOTONIC BOOLEAN  
FUNCTIONS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian  
Vol 24, No 8, Aug 84 (manuscript received 28 Jan 83) pp 1250-1257

GAYNANOV, D. N.

[Abstract] An optimality criterion different from Shannon's for decoding  
monotonic Boolean functions is examined and validated. Upper- and lower-  
bound estimates of the efficiency of the monotonic Boolean function decoding  
algorithm are made in accordance with the criterion. A decoding algorithm  
which is optimal in terms of the new criterion, as well as Shannon's and  
numerous others, is constructed for the class of monotonic Boolean functions  
generated by disjoint systems of linear inequalities. References: 6 Russian.  
[451-6900]

UDC 519.2

NEW APPROACH TO FREQUENCY PROCESSING IN METHOD OF OBSERVATION GROUPING AND  
OPTIMALITY OF CHI-SQUARE CRITERION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 2, Jul 84 (manu-  
script received 2 Oct 83) pp 287-291

IVCHENKO, G.I. and TSUKANOV, S.V., Moscow Institute of Electronic Machine  
Building.

[Abstract] A new algorithm is proposed for processing statistical data with-  
in the framework of the observation grouping method. The algorithm is more  
efficient than the Chi-square, maximum likelihood ratio, empty-box, etc.,  
algorithms ordinarily used for statistical hypothesis testing. Criteria  
more powerful than the ordinary Chi-square criterion are constructed. A  
theorem regarding asymptotic normality of generalized separable statistics  
is derived. References 8: 6 Russian, 2 Western.  
[22-6900]

UDC 519.9

SOLUTION OF LINEAR DIFFERENTIAL TRACKING GAME WITHOUT DISCRIMINATION OF  
A RETREATING OBJECT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 5, Aug 84  
(manuscript received 14 May 84) pp 1063-1066

PONTRYAGIN, L.S., Academician, USSR Academy of Sciences and MISHCHENKO, A.S.,  
Mathematics Institute imeni V.A. Steklov, USSR Academy of Sciences.

[Abstract] A linear differential game is described by  $\dot{z} = Cz - u + V$ . In this  
work, a solution is given for a tracking control  $u(t)$  without discrimination  
of the retreating control  $v(t)$ , assuming that certain differentiability  
conditions are satisfied. The sets  $\bar{W}(\tau)$  are assumed to be convex with  
smooth boundaries, and the boundaries of sets  $P(\tau)$  and  $C(\tau)$  contain no  
rectilinear segments. It is found that for an optimum control  $u(t)$  the  
solution  $z(t)$  of the differential game always satisfies the inequality  
 $\frac{d}{dt} T(z(t)) \leq -1$ , where  $T(z(t))$  is the value of the game. References:  
2 Russian.  
[15-6900]

UDC 519.9

SOLUTION OF LINEAR DIFFERENTIAL TRACKING GAME BASED ON ALTERNATED INTEGRATION WITHOUT DISCRIMINATION OF RETREATING CONTROL

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 6, Aug 84  
(manuscript received 28 Jun 84) pp 1330-1334

PONTRYAGIN, L. S., academician, and MISHCHENKO, A.S., Mathematics Institute  
imeni V. N. Steklov, USSR Academy of Sciences

[Abstract] A linear differential game is described by the equation  $\dot{z} = Cz - u + v$ , where  $z$  is a Euclidean vector belonging to vector space  $R$  of dimensionality  $n$ , and  $u$  and  $v$  are controls which are functions of time  $t$  and which satisfy the conditions  $u \in P$ ,  $v \in Q$ , where  $P$  and  $Q$  are convex compact subsets of the space  $R$  of arbitrary dimensionalities. It is assumed that the terminal set  $M$  is a certain convex set belonging to space  $R$ . The "tracking problem" was solved by the authors in a previous study, i.e., searching for a control  $u(t)$  so that its value is based on knowledge of  $z(s)$  and  $v(s)$  for  $s \leq t$ . In that study the retreating object was discriminated assuming that the convex set  $W_\tau$  has a smooth boundary which is a smooth function of  $\tau$  and that the set  $P$  also has a small boundary which contains no rectilinear segments. The present study does not use discrimination of the retreating objects; the selection of the optimum control  $u(t)$  is made more concrete. References 3 Russian. [37-6900]

UDC 519.622

CONTROLLING STABILITY OF EXPLICIT SINGLE-STEP METHODS FOR INTEGRATING ORDINARY DIFFERENTIAL EQUATIONS

Moscow DOKLADY AKADEMII NAUK SSR in Russian Vol 277, No 5, Aug 84 (manuscript received 13 Oct 83) pp 1058-1062

NOVIKOV, V.A. and Ye.A. NOVIKOV, Institute of Theoretical and Applied Mechanics and Computer Center, Siberian Department, USSR Academy of Sciences.

[Abstract] A method is proposed for controlling the size of the integration step for single-step integration of ordinary differential equations by controlling the accuracy and stability of the numerical scheme. The method is illustrated by constructing an integration algorithm based on the explicit Runge-Kutta second-order approximation formula. A numerical experiment with and without stability control is described in which the algorithm with control is approximately 1.3 times more accurate than the algorithm without control. References 5: 4 Russian, 1 Western. [15-6900]

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